VOL·XV NO·4

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

S·A·E

OCTOBER 1924

SOCIETY OF AUTOMOTIVE ENGINEERS INC
29 WEST 39TH STREET NEW YORK

A Watson Stabilator Is a Brake Which Is Automatically Applied Against the Rebound Or Upthrow of a Car Spring

FURTHER, this brake is automatically fixed in size to correspond to the force of the rebound.

If the car spring has been only slightly compressed and its rebound force is hence mild, the size of the Stabilator brake is automatically small.

If the car spring has been heavily compressed and its rebound force is hence violent, the size of the Stabilator brake is automatically large.

And the size of the Stabilator brake automatically varies with the varying forces in between these two extremes.

As the H. H. Franklin Manufacturing Company put it, "Stabilators control springs without hampering them." Franklin further says, "Stabilators are the first devices of the kind that really do the trick."

To sit on top of four uncontrolled car springs is like sitting on four good kegs of gun powder. And what motorist doesn't know it?

J. W. Watson

President

JOHN WARREN WATSON COMPANY
TWENTY-FOURTH AND LOCUST STREETS
PHILADELPHIA
(Detroit Branch: 51-53 Canfield Avenue, East)

WATSON
STABILATORS

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. XV October, 1924 No. 4

Chronicle and Comment

Opinion Divided on Bayonet-Type Doors

THE comments of passenger-car engineers as to the merit of the bayonet type of head-lamp door-construction are given on p. 274 of this issue.

The work of the Subdivision that has been requested to draw up a recommendation for door construction should be most valuable and indicate a means of overcoming the faults of the popular bayonet type of construction.

B. M. Smarr, of the General Motors Corporation, is the chairman of this Subdivision.

Dr. Lemon on Research Committee

BY the appointment of Dr. B. J. Lemon to membership on the Research Committee, as announced on p. 272 of this issue of THE JOURNAL, the Committee acquires the cooperation of an able and practical technologist in the field of rubber and tire research. In view of the many automotive problems now before the industry in which rubber enters as an important factor, it is believed that Dr. Lemon's services will add materially to the effectiveness of the committee's activities.

Shock-Absorber Competition in France

ANNOUNCEMENT has been broadcast by the City of Paris and the Department of the Seine that a competition will be conducted in France to determine the most satisfactory shock-absorbers at present available. It is understood that the contest is open to Americans and that prizes totaling 50,000 francs are available for award. Entries must be made before March 31, 1925, although the tests will not begin before Oct. 1, 1925.

The announcement states that interested parties may obtain all necessary information by addressing Direction des Travaux de Paris, Secretariat, Bureau 121, 98 Quai de la Rappee, Paris, France.

Automobile Traffic on Railroads

A STATEMENT, which was somewhat startling to those not closely acquainted with the subject, was made recently to the effect that automobiles pay the highest rate per ton-mile of any railroad traffic, and that, whereas wheat has been generally referred to as the "back-log" of the railroads' freight business in this Country, the automotive industry last year contributed to the railroads 50 per cent more freight business than did wheat. In this connection some interesting figures that have been collated by the Interstate Commerce Commission are available.

Body Standards Under Consideration

SUBDIVISIONS of the Passenger-Car Body Division have been appointed to draw up specifications for paints, varnishes and enamels and for leather substitutes. H. C. Mougey heads the Subdivision on Paints, Varnishes and Enamels and has submitted a preliminary draft of a specification for black baking-enamel as a basis for discussion. E. H. Nollau, of the E. I. du Pont de Nemours & Co., is chairman of the Subdivision on Leather Substitutes. The complete personnel of the former Subdivision and the specification proposed for baking-enamel are given in the section on Tentative Standardization Work and will be found on p. 273.

Adjusting Head-Lamps

IN the booklet recently issued by the National Automobile Chamber of Commerce, giving advice on the use of automobiles, the following brief note is given on the adjustment of head-lamps to prevent glare:

> Stand the car on level ground 25 ft. from and facing a wall.
>
> Draw a horizontal line on the wall at the height of the lamp center.
>
> Draw two perpendicular lines at the same distance apart as the two lamp centers.
>
> Adjust the focus of each light until the top of the bright part of the beam is flush with the horizontal line and so that the area of the bright part is divided evenly by the corresponding perpendicular.

For Production Progress

SELDOM has the Society been fortunate enough to secure a program of papers which promised as great value and interest as the comprehensive group scheduled for the Production Meeting in Detroit this month. The industry has rallied to the production meeting idea as never before. It has been found necessary to devote three days to the program of papers and factory visits. No member of the Society who is connected with the production branch of the industry should miss this meeting. This applies with equal truth to engineers who

recognize the value of keeping in touch with production matters. The announcement of the Production Meeting in Detroit, Oct. 22 to 24, is presented on p. 291 of this issue of THE JOURNAL.

Cheap Lamp-Sockets Cause of Failures

THE Lighting Committee of the Eastern Conference of Motor-Vehicle Administrators reported early this year that one of the causes of improper head-lamp illumination is cheap and consequently poorly constructed lamp-sockets. As a result of subsequent cooperative action, the S.A.E. Lighting Division has undertaken a study of this situation. Lamp sockets, properly made in accordance with the present S.A.E. Standard, are satisfactory for passenger cars at least. Consideration is being given, however, to the need for larger sockets and lamps, having ¾-in. diameter bases, for use on motor trucks and motorcoaches.

If the passenger-car manufacturers do not desire to see restrictive regulations adopted by the various States, head-lamps must be constructed so as to stay in focus under ordinary service conditions. The questionnaire that is being sent to all car manufacturers, as outlined in the article on lamp sockets on p. 275 of this issue, should receive careful consideration.

Dilution Factors Discussed

WHAT is the effect upon crankcase-oil dilution of the weather or the outside air temperature, the jacket-water temperature, the fuel volatility, the mixture-ratio, piston and ring design and piston fit? What are the injurious effects of dilution, and the danger-points in dilution and in viscosity? How often should crankcase oil be changed? These questions formed the basis of a questionnaire circulated among automobile and engine builders some months ago by the Research Department. The summary of returns that was published in the August issue of THE JOURNAL is supplemented in the Automotive Research columns of the present issue on p. 270, by a discussion of the various factors as they have been studied at the Bureau of Standards in connection with the cooperative fuel-research.

In the Automotive Research columns on p. 271 are given also an analysis of the conditions that accompany dilution and a presentation of the elementary physics that applies to the dilution process. This material was prepared for THE JOURNAL by one of our leading physicists and will doubtless be of interest to many of the members.

Pan-American Standardization Conference

A CONFERENCE on the general subject of the establishing of standards relating to both raw and manufactured products will be held at Lima, Peru, beginning on Dec. 23. This conference is being called by the Pan-American Union, the Peruvian Government having accepted the invitation of that organization to act as host. An advisory committee representing various elements of industry was appointed recently by Chairman Whitney of the American Engineering Standards Committee. E. A. Johnston, chairman of the Standards Committee of the Society, and director of engineering of the International Harvester Co., represents the automotive industry on this committee.

At the coming conference efforts will be directed wholly toward laying the foundation for creating more effective and general satisfactory commercial relations between the countries of North America and South America. A number of papers on various phases of standards work will be presented by men who have had experience in this field in the Americas and in Europe. The conference will be conducted along broad lines from an international point of view.

Joint Payment of Society and Section Dues

FOLLOWING the plans that have been discussed for some time, the Council has directed that, beginning with this fiscal year, the members shall be billed jointly for Society and for Section dues. By the time this issue of THE JOURNAL is in the hands of the members, they will have received bills embodying the purpose of this method. Those members of the Society who are also members of a Section have been billed for both National and local dues, and are expected to remit to the office of the Society for both of these payments.

The form of the bill sent to those members of the Society who are not Section members affords them the opportunity of indicating they would like to join a Section, and to do so promptly by remitting Section dues. It is the view of the Council that, in participating in local activities, the members should join the particular Section that has its headquarters nearest their residence or place of business. The respective Sections receive through the office of the Society the Section dues paid by members, in addition to appropriations to the Sections made by the Council from the treasury of the Society. The method of joint collection of National and Section dues was put into effect to provide the most convenient plan of payment to the members and to relieve the officers of the Sections of as much detail work as possible in the conduct of the local activities.

Automobile Stages

THE title of the paper prepared for the Automotive Transportation Meeting last month by Vice-President F. D. Howell, of the Motor Transit Co. of Los Angeles, was Some Notes on Automobile Stages in California. In using the word "stages" Mr. Howell referred, of course, to the type of highway motor-vehicle for which a demand has existed for a long time on the Pacific coast and in adjacent territories. Mr. Howell called attention to the fact that about 250 stage companies conducted common-carrier passenger-service in California last year, operating over 1000 vehicles and carrying approximately 25,000,000 passengers.

The use of the word "stage" indicates, perhaps, the necessity for some standardization of nomenclature for the various types of vehicle employed in highway common-carrier service. Already some confusion and rather marked difference of opinion have arisen in connection with the use of the words "motorbus" and "motorcoach." Up to the present time, the Society has used the words interchangeably. Representatives of leading companies producing vehicles of the kind in question urge the use of the word "motorcoach," largely, it is believed, with the idea of avoiding the suggestion in the mind of the public of "jitney," which they feel is the tendency when the word "motorbus" is used. Others refer emphatically to the fact that the word "motorbus" is well established in usage.

In the progress report of the committee of the American Electric Railway Association prepared for submission at the meeting of that organization scheduled to be held at Atlantic City this month, the word "motorcoach" is used to describe the type of highway passenger-vehicle that is being used in increasing numbers by the street-railway companies located in all parts of the Country.

Meeting with Railroad Club of New York

ONE of the most interesting sessions of the Automotive Transportation Meeting held last month was that conducted jointly by the Railroad Club of New York and the Society. President Dickerson of the former organization was particularly felicitous in welcoming the automotive brethren into the midst of the railroad men. It is believed that this inaugural joint discussion of mutual problems in the two fields of work will be followed by other similar meetings of a very helpful nature. The Railroad Club holds monthly meetings in New York City except during the summer. There was excellent evidence at the session held last month that the railroad executives work together effectively.

In presenting his paper entitled Small-Consignment Commodity-Distribution in London and its Environs, Mr. Paterson, of London, said that an equally good title for it would have been Store-Door Delivery. Mr. Paterson held the interest of those present very closely by his vivid description of the work of the large British delivery-system with which he is connected. His presentation of this paper was an important novel event, it being the first occasion of a leading exponent of European highway-delivery methods coming to this Country to give information on this subject in a formal way. The industry is indebted to Mr. Paterson for the splendid and gracious way in which he did this. Incidentally, Carter, Paterson & Co., Ltd., with which Mr. Paterson is connected has been doing business for a century.

Mr. Bean, of the New York, New Haven & Hartford Railroad, gave a very interesting address on his pioneer work in the operating of railway motor-cars. He stated that within a short time his company will have 26 of these automotive units running on regular schedule.

Hand-Signaling in Highway Traffic

SEVERAL years ago the National Automobile Chamber of Commerce advocated the inclusion in traffic regulations of the following provisions as to hand-signaling of drivers in automobile traffic:

> When turning the vehicle to the left, extend the arm in a horizontal position
>
> When turning to the right, extend the arm with the forearm at right angle
>
> When intending to stop, extend the arm and move it up and down in vertical position

In discussing a paper on traffic regulations at a meeting of the Metropolitan Section of the Society, J. W. Lord advocated that hand-signaling be abolished by law. He expressed the opinion that at night hand-signaling is futile and dangerous, particularly in view of the lack of enforcement of suitable head-lamp regulations. Mr. Lord believes that the crux of the situation is common courtesy; that if a man approaching a street corner wishes to turn to the right he should approach the curb 200 or 300 ft. before he gets to the corner, and gradually slow down; and that before making a turn to the left, the car should be driven toward the middle of the highway. This practice is followed in some cities, including New York City. The man who wishes to turn into a side street at the left can, if there is considerable traffic, when he comes to his corner, stop in the middle of the street without blocking traffic. The location of the car on the road indicates very definitely the direction in which the car is to be turned.

In the London police regulations, "Attention! Halt!" is expressed by the arm extended, the elbow bent, the fingers pointing upward. The arm extended horizontally means, "I am turning to the right." On the contrary, the direction, "I am turning to the left" is indicated by the arm being extended horizontally and moved back and forth from the shoulder, the fingers being curved. "I am stopping" is expressed by extending the arm horizontally, palm down, and moving the hand up and down. The signal for "Please pass me on the right" is given by holding the arm downward, palm forward, raising the arm with palm upward, lowering to original position and bringing forward again.

In presenting recently his paper entitled Observations of a Superintendent of Motor-Truck Fleet Operation, J. F. Winchester referred to the hand-signaling system recommended by Special Deputy Police Commissioner Harriss, who is in charge of highway traffic in New York City. According to this, when turning to the left the arm should be extended and the first finger pointed to the left; to signal intention to stop, the arm should be extended with the back of the hand to the rear of the car; to signal intention to back-up, the arm should be extended with the palm of the hand to the rear of the car, motioning in a backward direction; and to signal intention to turn completely around, the arm and hand should be circled three times forward to indicate a turn to be made to the right, or circled backward to indicate a left turn.

Obviously, some standard method of hand-signaling should be used throughout this Country, or throughout the world. Commissioner Harriss believes that this is about the first thing that should be done in standardizing traffic regulations. There is a commonly used "come forward and pass me" signal, this being given by motioning the hand in a forward direction from the elbow to the wrist. In Mr. Harriss' opinion no necessity exists for designating a signal for a right-hand turn, the important signal being that indicating intention to swing across the path of following vehicles, as in a left turn. He feels that less confusion will be caused if there is no right-hand-turn signaling. He has observed, however, that in a case where without a right-hand-turn signal a turn might be dangerous, the signal that he recommends for use when intending to stop could be employed satisfactorily.

INTERNATIONAL DEBTS

IN 1914 the United States was a debtor nation in the amount of perhaps \$2,000,000,000 to \$2,500,000,000 net. In 10 years' time the situation has been transformed, and the United States, now the chief reservoir of capital, is a creditor to the amount of approximately \$20,000,000,000, of which approximately \$12,000,000,000 represents amounts owed by foreign governments to the United States Government. Not counting this latter sum American investments abroad at the end of 1923 have been estimated by the Department of Commerce at about \$8,000,000,000. Foreign investments in the United States at that date, according to an estimate of the Department of Commerce, were perhaps \$3,000,000,000. Therefore a balance of about \$5,000,000,000 remained, representing the net amount for which American nationals are creditors with respect to foreign countries, apart from the amounts that were owed by the governments of the various nations to the Government of the United States.—A. N. Young.

AUTOMOTIVE RESEARCH

The Society's activities as well as research matters of general interest are presented in this section

THE DANGER-POINT OF DILUTION

Cooperative Fuel Research Throws Light on Important Factors

Twenty-six builders of automobiles and engines presented their views on the dilution problem in answer to a questionnaire circulated some months ago by the Society's Research Department. A summary of the returns was published in the August issue of THE JOURNAL, p. 117. In order that the discussion of the important dilution factors may be more complete, it is believed worthwhile presenting the conclusions that have come from the experimental work conducted at the Bureau of Standards in connection with the cooperative fuel investigation. The points discussed in the following contribution from the Bureau are those referred to in the replies from the industry.

EFFECT OF WEATHER OR OUTSIDE AIR TEMPERATURE

The indirect effect of air temperature upon the rate of dilution may be considerable, but its direct influence appears from the results obtained in the Cooperative Fuel Research to be rather small. Figs. 22 and 23 of an article by the late Stephen M. Lee, entitled Economic Motor-Fuel Volatility[1] in the July, 1923, issue of THE JOURNAL show the direct influence of this factor. If, as suggested, however, the outside air temperature prolongs the starting period, it will for that reason exert a major influence on the rate of dilution. Table 5 of the article referred to above shows a dilution of 23 per cent after 2-hr. operation without ignition as compared with a dilution of less than 4 per cent with the engine operating under its own power but with conditions similar otherwise. This shows that a considerable amount of dilution may take place during the starting period. In this same article it is shown that the rate of dilution is closely related to the richness of the mixture and, if weather conditions are such as to require an enrichment of the mixture, they will very probably cause an increased rate of dilution.

EFFECT OF JACKET-WATER TEMPERATURE

The Cooperative Fuel Research shows that the jacket-water temperature exerts a major influence upon the rate of crankcase-oil dilution. As was stated in the paper that J. O. Eisinger presented at the 1924 Summer Meeting, entitled Factors Affecting the Rate of Crankcase-Oil Dilution[2], this influence appears to be due to the effect that the temperature of the oil-film on the cylinder-walls has upon the rate at which the diluent is eliminated from that film.

EFFECT OF FUEL VOLATILITY

The Cooperative Fuel Research has shown very clearly that an increase in the rate of crankcase-oil dilution accompanies a decrease in fuel volatility. In this connection it must be remembered that the user of a fuel is apt to judge its volatility by the ease with which he can start his engine. This depends very largely upon the proportion of light constituents that the fuel contains, whereas it is the heavy constituents of the fuel which are found in diluted oil.

EFFECT OF MIXTURE-RATIO

The Cooperative Fuel Tests have shown the rate of dilution to be very closely related to the richness of the mixture. No marked change in the rate of oil contamination by carbon has been observed with a change in the mixture-ratio, although it is entirely possible that such a change might take place.

EFFECTS OF PISTON AND RING DESIGN AND WEAR AND PISTON FITS

Figs. 5 and 6 of Mr. Eisinger's paper touch upon this phase of the problem, and further investigation is in progress. It is extremely difficult to determine the influence of these factors from service tests or from the ordinary dynamometer test. The reason for this lies in the fact that these factors are very likely to exert a considerable influence upon the rate of oil consumption. The percentage of dilution depends upon the rate of oil consumption, as well as upon the rate at which the diluent enters the oil. A change in piston design might cause a reduction in the percentage of dilution and for that reason appears to be desirable. Further examination, however, might reveal that the change in design had actually caused an increase in the amount of fuel that entered the oil but that the frequent replenishment of oil made necessary by the increase in consumption had more than overbalanced this influence. Such being the case, the change in design could hardly be considered beneficial.

INJURIOUS EFFECTS OF DILUTION

In connection with the Cooperative Fuel Research some work has been done in comparing the lubricating properties of a diluted oil with those of an undiluted oil of equal viscosity. There have been indications of a slight difference in oiliness, but the work has not progressed to an extent to justify the drawing of definite conclusions. As regards the injurious effect of using an oil of improper viscosity, the harm may come from the use of an oil of too high viscosity in order that its viscosity may be adequate after considerable dilution has taken place, or it may result from the use of an oil whose viscosity has been reduced by dilution until it has become inadequate.

DANGER-LINE OF VISCOSITY

It is not surprising that the questionnaire circulated among manufacturers did not show engineers to be in agreement with respect to the safe minimum values of viscosity or permissible percentages of dilution. The minimum permissible viscosity undoubtedly depends upon the design of the engine and the conditions under which it operates. So far as the permissible percentage of dilution is concerned, this is contingent upon the viscosity of the undiluted oil. In general the higher the viscosity of this oil the greater the amount of dilution that can take place before the viscosity becomes too low for satisfactory operation. It is not impossible that the real danger lies in the use of oils of too high viscosity in an endeavor to counteract the effect of the dilution. Whatever may be the facts concerning safety, without question the use of oils of higher viscosity than necessary causes an increase in engine friction and may seriously affect the economy.

HOW OFTEN SHOULD OIL BE CHANGED?

The frequency with which oil should be changed depends almost entirely upon the conditions under which the car is

[1] See THE JOURNAL, July, 1923, p. 3.
[2] See THE JOURNAL, July, 1924, p. 69.

operated. In certain instances it may depend upon the rate of sludge formation rather than upon the rate of dilution.

DILUTION PROCESS EXPLAINED

Some Elementary Physics Applied to the Problem of Crankcase-Oil Dilution

The following analysis of conditions accompanying the dilution of crankcase oil and explanation of the process itself were prepared for these columns by one of our leading physicists. It should be of considerable interest to those engaged in studying the dilution problem.

Some Elementary Physics

Much dilution of crankcase oil certainly occurs when the choke is used in starting. The amount of raw fuel that enters the cylinders in this way and the percentage that gets into the crankcase depend on many things not susceptible of analysis on any systematic basis, and no attempt will be made here to discuss this phase of crankcase-oil dilution.

However, certain well-established physical facts and principles may be applied to the behavior of the fuel and oil in an engine in operation on a fuel-air mixture that even remotely approaches the condition for normal operation. A consideration of these principles may throw some light on the observed facts regarding crankcase-oil dilution.

The conditions of operation are somewhat as follows: (*a*) the cylinder-walls, particularly the side walls, are covered with a film of oil not more than a few thousandths or perhaps a few ten-thousandths of an inch thick, which is at a temperature not far from that of the metal of the cylinder walls; (*b*) the fuel-air mixture entering the cylinders is within the range of combustibility, and the fuel that it contains is at least partly vaporized, any liquid that remains being in small droplets distributed with some degree of uniformity throughout the charge; (*c*) the fuel in the mixture is made up of various constituents of differing volatility and when vaporizing in the presence of its own vapor it has a definite dewpoint temperature for any given mixture proportions, the existence of a definite dewpoint temperature above which the fuel will vaporize entirely having been shown by different experiments and the temperature having been determined for various grades of gasoline and (*d*) the oil film on the cylinder walls is being constantly interchanged with oil from the crankcase by the motion of the piston. If two pails, one containing fresh oil and the other diluted oil, were placed side by side and a spoonful of fresh oil were first added to the diluted oil, then a spoonful of diluted oil to the fresh oil, ultimately the two pails would contain the same mixture. The motion of the piston at each stroke, carrying some oil from the crankcase up toward the combustion-chamber and some from the combustion-chamber down toward the crankcase, acts in the same way, so that if the oil on the cylinder-walls always contained a definite amount of fuel, eventually the oil in the entire system would have this same composition, provided no fuel were gained or lost in the crankcase or elsewhere outside the cylinders.

With this picture in mind of the condition in an engine under normal operating conditions, let us consider how the fuel must behave. On entering the cylinder during the intake stroke, the charge probably, though perhaps not always, contains some liquid spray. If present, this spray or part of it strikes the cylinder-walls, piston-head and other parts and attempts to mix with the film of oil. Will the fuel actually mix with the oil or not?

The cylinder at the closing of the intake-valve contains a charge of air at a pressure of from, say, 6 to 14 lb. per sq. in., depending upon the throttle opening, mixed with fuel vapor, if all the fuel were evaporated, having a vapor-pressure of something under 2 per cent of the air pressure. The presence of the air can, of course, be neglected so far as the behavior of the fuel vapor is concerned, as we know from Dalton's law, except possibly that the evaporation or the condensation of the fuel will take place somewhat more slowly with air present.

Dewpoint Temperature

The fuel then, partly liquid and partly vapor, is present for the instant in such an amount that the vapor pressure is something less than ½ in. of mercury. For any given total amount of fuel present, as noted above, a temperature exists which is known as the "dewpoint temperature," at which the first drops of fuel will condense on cooling, or the last drop will evaporate on heating. This temperature depends upon the quality of the fuel and the mixture-ratio.

Assume for the moment that this dewpoint temperature is 100 deg. fahr. for the conditions predicated above. When the surfaces are covered with oil, the dewpoint temperature may differ somewhat from that for dry surfaces of metal, but it is assumed that this 100-deg. fahr. dewpoint applies to oil-covered surfaces. If the temperature of the cylinder-walls is above 100 deg. fahr., any liquid fuel striking them will tend to evaporate and in so doing it will absorb heat from the oil-film and cool it below the original 100 deg. fahr. In fact, it is due to this cooling alone that fuel can go into solution in the oil.

The amount of evaporation of the fuel which can take place in the surface film of oil, therefore, will depend on how rapidly heat can be supplied to the oil-film, and thus to the liquid fuel, by conduction from the cylinder-walls and by contact with the gases in the cylinders. The average amount of dilution which will exist in the oil-film on the cylinder-walls will depend upon the relation between the rate at which the fuel strikes the walls and the rate at which heat is supplied to vaporize this fuel.

Some estimate of these rates can be had as follows: The evaporation of the fuel charge in the air will lower the air temperature about 60 deg. fahr., while the burning of the charge would raise the temperature about 3600 deg. fahr. In other words, the amount of heat produced is about 60 times that required to vaporize all the fuel.

Since some 20 per cent of the heat of combustion escapes through the cylinder-walls, including the oil-film on their surface, to the water-jacket, it is obvious that for each cycle at least 12 times as much heat passes through the oil-film as would be required to vaporize all the fuel used in that cycle. It is obvious, therefore, that plenty of heat is available to vaporize all the fuel striking the cylinder-walls.

Factors Governing Complete Evaporation

Another factor, however, is involved. If the temperature of the oil-film and the cylinder-walls is below the dewpoint of the fuel mixture, complete evaporation will not take place because the available heat is absorbed by the water-jacket. If, however, the cylinder-walls are only a *little* above the dewpoint, the heat supply for evaporation is ample. It would be concluded, therefore, that the cylinder-wall, and therefore the jacket-water, temperature controls very directly and definitely the average composition of the oil-film on the cylinder surfaces, as regards its fuel-content. This seems to be in entire accord with experimental results.

Moreover, whatever the *average* dilution of this oil-film, this will be the *ultimate* dilution of the crankcase oil, assuming that fuel is not eliminated in the crankcase itself. The length of time it will take for the dilution to become constant in the crankcase will depend, of course, on the piston and ring fits, the speed of operation and the like; in other words, on the size of the spoon and the rate of dipping from the diluted oil to the fresh oil container. This indicates that the equilibrium amount of dilution for any given set of operating conditions should be fairly definite, a conclusion that accords with experimental results but that has been reluctantly accepted because without the foregoing analysis it appeared illogical.

Experiments have indicated that crankcase-oil dilution does not depend directly on piston-head temperature. This seems to be a rational conclusion, in fact almost necessary for the following reason. The piston-head temperature

under average operating-conditions is much higher than that of the cylinder-walls. If, therefore, the cylinder-walls are at a temperature anywhere near the dewpoint, such that dilution is not very excessive, then the piston-heads are hot enough so that all the fuel which strikes them is evaporated. Naturally, this temperature has little effect on dilution, unless conditions are very bad indeed, in which case it would be difficult to isolate the effect of the piston-head temperature.

Another fact that conforms to this analysis is the close relation between fuel volatility and crankcase-oil dilution. The dewpoint temperature of the fuel-air mixture depends on the fuel volatility, though not directly on the distillation end-point; therefore, the heavier or less volatile the fuel, the higher will be the jacket-water temperature required to prevent dilution, or, conversely, the greater the amount of dilution under the same operating conditions. Again, the dilution should increase, as it does, with increase in the mixture-ratio, for the dewpoint temperature increases with fuel content as well as with decreased fuel-volatility.

It has been shown also that the temperature, and therefore supposedly the degree of vaporization, of the incoming charge have much less effect on crankcase-oil dilution than might be expected. This also tallies perfectly with the above analysis. The dewpoint temperature does not depend upon the intake temperature; hence, the temperature of the cylinder-walls at which dilution stops should not depend primarily on intake-charge temperature, nor should dilution depend upon it directly. In fact, even if the fuel were entirely evaporated before entering the cylinders, condensation on the cylinder-walls and consequent dilution would occur, if the cylinder-walls were below the dewpoint temperature.

This discussion, as noted at first, is based upon consideration of what happens after the engine is in normal operating-condition, and more or less tacitly presupposes something approaching an average operating-condition, which of course does not exist in practice. The conclusions reached, therefore, are only qualitative, not absolute. In particular, the last one is modified by the fact that with a well-heated manifold the amount of raw gasoline injected into the cylinders in the process of "warming up" is likely to be much less than where less heat is used. Therefore, this important source of dilution, not included in the foregoing discussion, may be much reduced by the use of a manifold that heats rapidly.

CONCLUSIONS

From this discussion, the following conclusions may be summarized, as representing what should occur under general average operating-conditions. Crankcase-oil dilution

(1) Depends primarily on the average temperature of the cylinder-walls
(2) Reaches a substantial equilibrium amount, if the effect of use of the choke in starting is not too important a factor
(3) Represents in time the average dilution existing on the cylinder-walls, also barring too great effect of the use of the choke
(4) Depends directly on fuel volatility
(5) Depends directly on the average mixture-ratio
(6) Does not depend much upon the piston temperature
(7) Does not depend much upon the charge temperature or the degree of vaporization

The rate at which equilibrium is established, but not directly the equilibrium amount of dilution, depends upon the rate of interchange of oil between the crankcase and the combustion-chamber.

SEPTEMBER COUNCIL MEETING

THE meeting of the Council held at Detroit on Sept. 16 was attended by President Crane, First Vice-President Johnston, Vice-Presidents Strickland, Patitz and Ware, and Councilors Brumbaugh, Hunt, Rumney and Chryst. H. D. Church and T. J. Litle, Jr., nominees for the 1925 Council, were also present.

The financial statement as of Aug. 31, 1924, showed a net balance of assets over liabilities of $164,592.06, this being $28,151.92 more than the corresponding figure on the same day of 1923. The net revenue of the Society for the first 11 months of the fiscal year ending Oct. 1, 1924, amounted to $221,990.15. The operating expense during the same period was $197,936.71.

A budget for the ensuing fiscal year commencing Oct. 1, 1924, was approved on the basis of an expected income of $296,000.00.

Discussion was had as to plans for coming meetings of the Society.

Eighty-six applications for individual membership were approved. The following transfers in grade of membership were made: From Associate to Member, C. T. Olson; Junior to Member, Joseph C. A. Straub and J. George Oetzel; Junior to Associate, Ralph F. Beck, Albert A. Forster, J. Malcolm Randall, Neil Thayer Sawdey, William G. Schneider, Edward A. Rapin, Leslie E. King, Charles B. Moran and James B. Taylor, Jr.; Service Member to Member, Earle V. Schaal, Charles F. Taylor, William F. Butler, William Henry Petit and Edward R. Rounds.

It was reported that on Sept. 15 there were 5695 on the rolls of the Society, including Affiliate Member Representatives and Enrolled Students, as compared with 5631 on the same day of 1923.

The following subjects were assigned to Divisions of the Standards Committee:

Motor-Truck Bumpers—Truck Division (transferred from Parts and Fittings Division)
Voltage of Electrical Systems on Gasoline Motorbuses—Electrical Equipment Division

B. J. Lemon was appointed a member of the Research Committee.

It was announced that W. S. James had accepted appointment, as successor to Dr. H. C. Dickinson, of the Bureau of Standards, on the Advisory Board to Technical Committee on Lubricants and Liquid Fuels.

It was understood that the next Council meeting would be held in Detroit at some convenient date in connection with the Production Meeting of the Society scheduled to be held there Oct. 22 to 24.

LIGHTING THE MOTORBUS

TWO errors occurred in the illustration and table that appeared on p. 260 of the September issue of THE JOURNAL in connection with the article by W. C. Brown entitled Lighting the Motorbus. In the illustration that appeared above the table, the type of luminaire marked "diffusing glass" should appear at the upper right instead of in the upper central position and the type marked "clear prismatic glass" should appear at the center of the upper row instead of in the upper right corner. If this transposition is made, the table and the illustration will be in agreement. In connection with the Glare rating of $A+$ that appears in the third line of the table, the reference should be to footnote 5, printed underneath the table, instead of to footnote 4 as indicated.

TENTATIVE STANDARDIZATION WORK

Criticism of all tentative reports should be sent to the Standards Committee in care of the Society

PAINT SUBDIVISION APPOINTED

Specifications Suggested by H. C. Mougey for Black Baking-Enamel

For the purpose of developing standard specifications for the more widely used paints, varnishes and enamels, the following Subdivision of the Passenger-Car Body Division has been appointed:

H. C. Mougey, *Chairman*	General Motors Research Corporation
J. Warren Armitage	John L. Armitage & Co.
J. C. Brier	University of Michigan
E. M. Flaherty	E. I. duPont de Nemours & Co.
H. A. Gardner	Paint Manufacturers Association
W. H. Graves	Packard Motor Car Co.
J. O. Hasson	Sherwin-Williams Co.
L. V. Pulsifer	Valentine & Co.
C. L. Schumann	Pratt & Lambert
W. J. Sohlinger	Flint Varnish & Color Works
A. E. White	University of Michigan
W. P. Woodside	Studebaker Corporation of America

The accompanying specification for black baking-enamel has been suggested by H. C. Mougey, to serve as a starting-point for the Subdivision work. Criticism of the specification by members who would like to have definite standards established for this material will be appreciated by the Subdivision.

Suggested Specification for Black Baking-Enamel

(1) *General.*—This specification covers a high-grade black baking gloss enamel to be applied by a baking process to metal parts, such as fenders.

(2) *Durability.*—The requirements as to durability are that the enamel shall give the maximum durability in actual service, consistent with other properties, such as baking time, baking temperature, luster and flowing properties. The final decision as to durability shall be based on actual service tests but, as a guide in selecting enamels for actual service test, and in selecting enamels for use when not enough time is available to make service tests, the following tests are recommended.

(3) *Consistency.*—The enamel must be furnished in such a consistency that when reduced with gasoline in the ratio of one part of gasoline to four parts of enamel, poured on a panel of 100-lb. tin, and allowed to drain in a vertical position for 15 min., it will give a film that when properly baked will have a thickness of between 0.0008 and 0.0010 in. measured 3 in. from the top. In case the enamel is furnished in such consistency that it requires a greater or less amount of thinner than that specified above, the required amount of thinner may be used provided the non-volatile matter in the enamel as thinned for the test is not less than 33 per cent by weight.

If it is necessary to use a different amount of thinner than 25 per cent by volume of the unreduced enamel, the percentage of thinner required should be stated, as all comparisons of cost shall be made on the enamel reduced to working consistency.

Before an enamel is approved for production, a test should be made on keeping qualities, and all enamels that "liver" or thicken greatly on storing for several months in the containers should be reported as unsatisfactory.

(4) *Baking Time and Temperature.*—The baking time of the enamel, when applied as described in paragraph 3, shall be not less than 1½ hr. at 400 deg. fahr. and not more than 3 hr. at 400 deg. fahr. Tests should be made in a gas-heated oven in which the temperature is accurately and uniformly controlled, the temperature being 400 deg. fahr. when the test panels are placed in the oven. Indirect heating shall be used to prevent gas fumes from being discharged into the oven where the tests are made.

(5) *Tests on Baked Panels.*—To determine the correct time, four panels of the enamel, when applied as described in paragraph 3, will be baked at 400 deg. fahr. One panel will be removed from the oven at the end of 90 min., one at the end of 120 min., one at the end of 150 min., and one at the end of 180 min. These panels will be allowed to stand over-night and then tested as described below. At least one panel shall satisfactorily meet all requirements.

(*a*) The finish produced shall be a dense black, smooth and with a deep luster
(*b*) The film shall be so hard that it may be scratched with the finger nail only with great difficulty or not at all
(*c*) The enamel shall not wrinkle. A small amount of wrinkling on heavy "fatty edges" is permissible
(*d*) The toughness of the film shall be such that the panel may be bent 180 deg. on a diameter of ⅛ in., without the enamel showing any signs of cracking at the bend
(*e*) The film produced by the enamel shall stand immersion for 24 hr. in kerosene at room temperature without softening or blistering. This test shall be made by testing with the finger nail, in comparison with another section cut from the test panel and held as a standard without immersion in kerosene

(6) *Chemical Composition.*—The enamal as submitted by the manufacturer shall meet the following chemical requirements:

(*a*) The enamel shall be free from pigment
(*b*) The ash shall not be over 0.50 per cent
(*c*) The non-volatile matter shall not be less than 40.0 per cent. The non-volatile matter shall be determined by drying a sample of from 1.5 to 3.0 grams in a pint friction-top lid in an oven for 5 hr. at 115 to 120 deg. cent. (239 to 248 deg. fahr.)

(7) *Practical Tests.*—The enamel shall work satisfactorily as determined by a practical test in the enameling department of the factory, before it is finally approved. Drying time is specified for purposes of test at 400 deg. fahr. since at higher temperatures the time is reduced so greatly as to make accurate tests very difficult. In actual production the temperature of baking may be above or below 400 deg. fahr. as desired, and the practical test specified shall

be made using regular production temperatures and times. As an example of how baking time varies with temperature the following approximate table is given.

APPROXIMATE RELATIVE TIME REQUIRED FOR BAKING BLACK BAKING-ENAMEL AT DIFFERENT TEMPERATURES

Time, Hr.	Temperature, Deg. Fahr.
4	325
3	335
2	355
1	400
½	445
¼	490
⅛	510

The above tests are recommended for black baking-enamels composed of the materials usually used in making black baking-enamel. Special compositions may give a product to which the above empirical tests do not apply. Such special compositions should be tested by exposure test on panels exposed at an angle of 45 deg. facing the South, in comparison with other samples of known performance; in addition, tests in actual service should be made before the enamel is approved.

OUTBOARD ENGINES TO BE STANDARDIZED

At the suggestion of one of the magneto manufacturers, the Standards Department has taken up with the manufacturers of motorboat outboard engines the desirability of standardizing the magneto-mounting dimensions and shaft taper for engines using flywheel magnetos. It is believed that standardization of such dimensions as will permit interchangeability of engines and magnetos will be of benefit to both the engine and the magneto manufacturers. The suggestion is meeting with the approval of the engine manufacturers and a Subdivision of the Electrical Equipment Division will probably be appointed to develop tentative specifications.

BAYONET-TYPE LAMP-DOOR CRITICISED

Car Builders Divided on Approving This Type of Door as Standard Construction

The adoption of a specification recommending what is considered good head-lamp door-construction, so far as closing and fastening are concerned, has been under the consideration of the Lighting Division for several months. A subdivision was appointed in January to draw up a preliminary report. The personnel is B. M. Smarr, of the General Motors Corporation, chairman; C. D. Ryder, of the Cincinnati Victor Co.; W. F. Thoms, of the Indiana Lamp Co.; H. H. Oetjen, of the Edmunds & Jones Corporation; H. M. Lucius, of the Maryland State Board of Motor Vehicle Inspection; and G. P. Doll, of the Thomas J. Corcoran Lamp Co.

The following recommendation was submitted at the Lighting Division meeting on April 28:

> The head-lamp door shall be assembled to the body in connection with the reflector by exerting a force in a direction parallel to the axis of the lamp. The force required to assemble the door shall be maintained as compression on the sealing material by a convenient locking device, such compression to be set or released from the outside of the lamp by a mechanical device that will remain assembled to either the lamp, the door or the lock-ring when the compression is released. While the above general type of door construction is recommended, certain forms and combinations of materials making up what is commonly known as the bayonet lock are recognized as making an easily operated door, and it is recommended that, when this type of construction is used, one of the metals at each point of contact between two metals, where there is an abrasive action, shall be a non-ferrous metal.

After considerable discussion, the Division voted to retain the first paragraph of the report, to omit the second paragraph and to add the following:

> Suitable means shall be provided in the lamp construction to prevent the lamp glass from falling from the part to which it is assembled, when the lamp is opened.
>
> *Note.*—At the time the above recommendation was considered by the members of the Lighting Division, it was felt that the bayonet type of head-lamp door-construction should not be recommended, but that with improvements in design of this type of construction or where door and lamp parts in contact with each other are made of non-ferrous or non-corroding material, a satisfactory specification may be recommended in the future.

Since the meeting of the Division, rather severe criticism of the action taken was received, which indicated that the subject should be considered further.

To get a definite expression of opinion from the lamp and the car manufacturers as to the proposed recommendation, the following information was solicited:

> Opinion regarding the proposed recommendation.
>
> Experience in using head-lamps with bayonet type of door construction.
>
> Attitude with regard to using them in the future.
>
> Whether a recommendation should be adopted by the Society, either for or against such a specification.
>
> Suggestions as to what such a specification should be.

Marked differences of opinion were brought out by these questions. Fifteen of 25 of the leading companies reported that they would not use the bayonet type of construction in the future; six that they would use it; and four that they would use it only in improved form.

The following comments are abstracted from letters received from passenger-car manufacturers:

> Door-fastening devices are in a period of development. It is too early to adopt a standard.
>
> When modified to overcome corrosion, the bayonet type may be all right. A positive ground is essential.
>
> The bayonet type construction is not satisfactory for large head-lamps, although it may be fairly satisfactory for small ones.
>
> We do not think well of the recommendation, as any door construction permitting easy access will cause a great increase in bulb thefts.
>
> The bayonet type is suitable where the cost of the head-lamps is an important factor.
>
> We used the bayonet type for some time and experienced considerable trouble with the rims coming off when going over rough roads.
>
> We have never been able to get a lamp door that would stay in place with the bayonet-type construction.
>
> The bayonet type of door is all right if it is not corroded so that it works too hard and does not cause insufficient ground-contact.
>
> The bayonet type frequently binds so that it is very difficult to disengage the cover.
>
> The rusting out of the bayonet lock causes the door to rattle and eventually fall out.
>
> We are not at all satisfied with the bayonet type of construction. It never did work except on paper.
>
> The bayonet type of door in service has been generally unsatisfactory.
>
> We have used the bayonet type of door for last 10 years and have found it highly satisfactory, economical and practical.
>
> We have never found the bayonet type satisfactory. The doors fall off, are lost or stick so that it is impossible to remove them.
>
> We have experienced considerable trouble with the bayonet type of door construction, due mostly to faulty workmanship and rusty contact-parts.
>
> We like the bayonet type except that it is hard to operate and doors sometimes fall off.

We have been using head-lamps with the bayonet type of door construction for several years and found them very satisfactory and economical.

HEAVIER LAMP-SOCKETS PROPOSED

Lighting Division Submits Three Proposals to Vehicle Makers for Comment

One of the most troublesome things that automobile manufacturers have to contend with is unsatisfactory performance of electric-lamp bases, sockets and plugs. Many complaints have been received by the Lighting Division, as has been reported in articles appearing in the April, May and September issues, pp. 385, 489 and 185 respectively. Investigations indicate that the trouble is frequently due to the demand of the purchasers for cheap and consequently inferior products.

Two principal complaints have been considered as really justified: One, that in two-wire or double-contact fittings the clearance between the conductors and between the conductors and metal shells is not sufficient, due largely to cheap material and construction; the other, that fittings as now made will not withstand the more severe conditions of service on motor coaches and motor trucks.

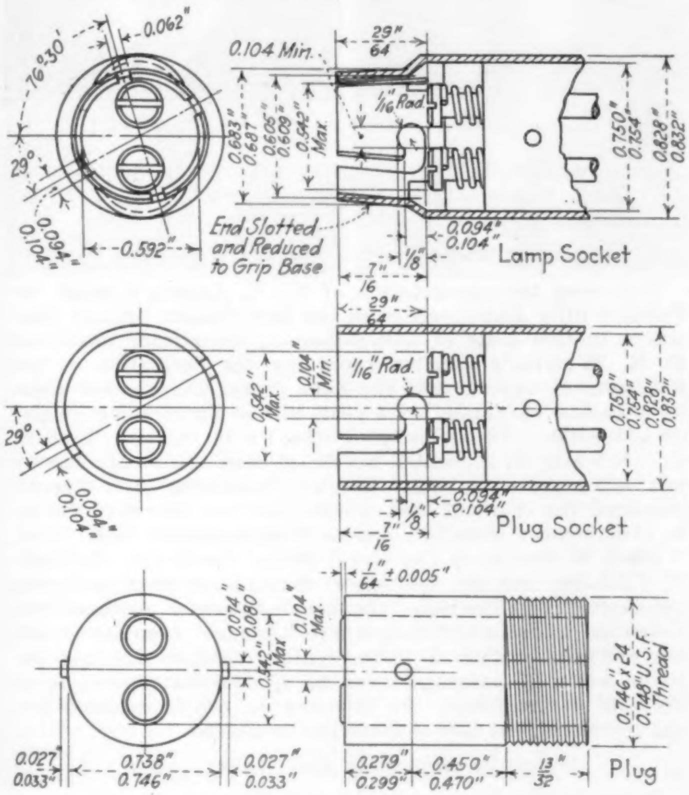


FIG. 1—¾-IN. SOCKETS AND PLUGS FOR STANDARD BASES

The members of the Lighting Division feel that although fittings properly made in accordance with the present S.A.E. Standards on p. B5 of the S.A.E. HANDBOOK will cost a little more initially they will be more satisfactory and less expensive in the long run for use on all types of vehicle. An alternative is to establish standards for a larger type of fitting.

To determine what equipment would best meet the requirements of the industry, the following proposals have been submitted to the manufacturers for comment:

(1) To use S.A.E. Standard fittings of better materials and construction than are used at present
(2) To use the present S.A.E. Standard ⅝-in. diameter lamp-base with a new standard ¾-in. diameter plug and socket as shown in Fig. 1
(3) To adopt a new standard for ¾-in. diameter lamp-bases, plugs and sockets as shown in Figs. 2 and 3

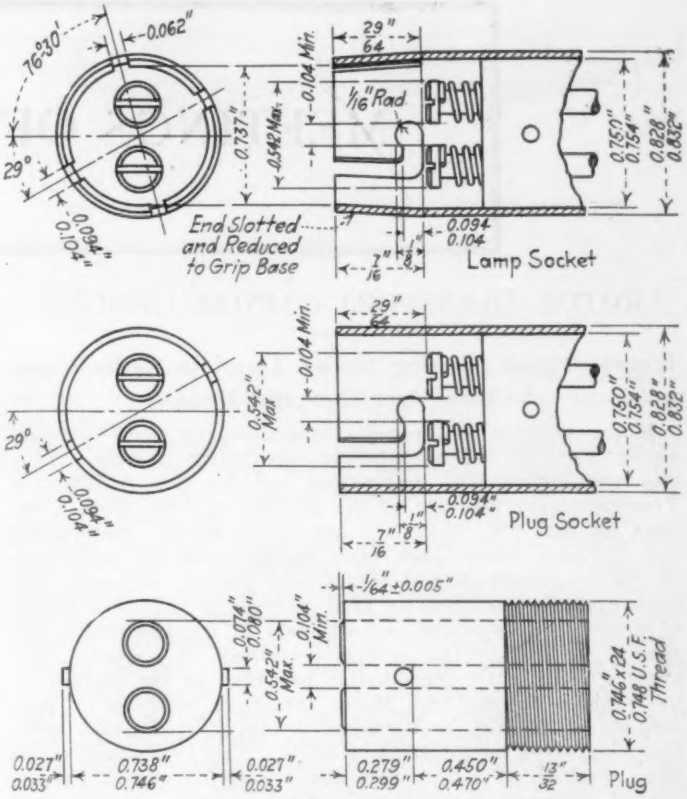


FIG. 2—¾-IN. SOCKETS AND PLUGS FOR ¾-IN. LAMPS

In considering these proposals, it must be borne in mind that the introduction of a new size of lamp, plug and socket would necessitate redesigning the head-lamps and other lamps and require new tools, fixtures and manufacturing equipment for making such fittings. A disadvantage of the second proposal is that plugs and lamps would not fit the same sockets.

The approximate cost of equipment made in accordance with these three proposals is given in the accompanying table. These costs were secured directly from the manufacturers.

APPROXIMATE COST IN CENTS OF BASES, SOCKETS AND PLUGS

Equipment	Proposal No. 1	Proposal No. 2	Proposal No. 3
Lamp, 21 cp.	35	35	75
Lamp Socket	6 to 8	12 to 14	12 to 14
Connector	6 to 8	2 to 14	12 to 14
Plug and Cap	4½ to 5	7 to 8	7 to 8

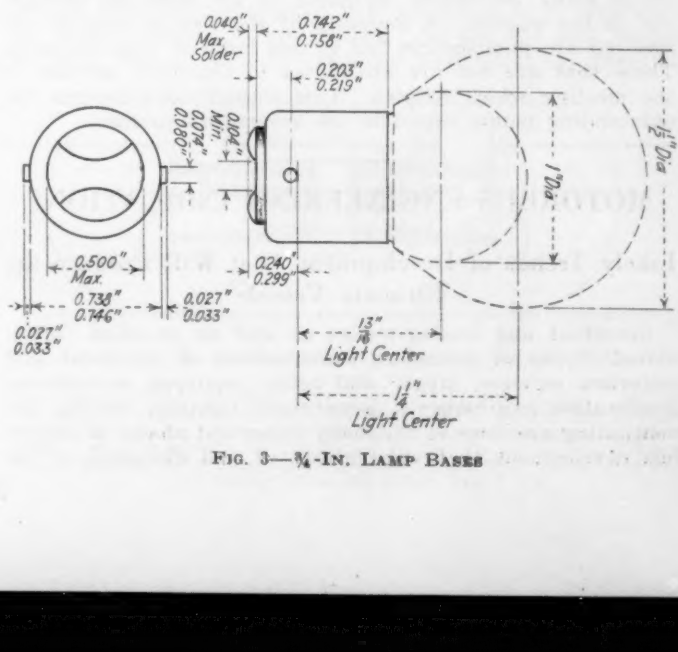


FIG. 3—¾-IN. LAMP BASES

MEETINGS OF THE SOCIETY

MOTOR TRANSPORT GAINING GROUND

Transportation Meeting Shows Trend in Commercial-Vehicle Operation and Design

Motor vehicles are rapidly strengthening their position as an arm of the national transportation system. This was the outstanding impression left by the Automotive Transportation Meeting of the Society in New York City, Sept. 18 and 19. Not only are motor trucks, motorbuses and rail-cars being taken more seriously by the adherents of the longer-established steam and electric railways, but these agencies are showing keen interest in the development of motor vehicles to the highest state of transportation efficiency. It is clear that scientific methods of operation are keeping pace with engineering progress in the design of the vehicles themselves. Motor transport, whether of passengers or freight, is becoming a highly specialized business conducted on an efficient basis. The haphazard operating methods of a few years ago are giving way to clearly defined engineering principles. What is more, the operator is exerting a strong influence on the design of the vehicle needed for his service. Several of the papers at the Transportation Meeting set forth recommended alterations in design for the specific purpose of better fitting buses and rail-cars to their respective services, reducing the expense of maintaining them and insuring an increased revenue to the operator.

It is noticeable that well-managed organizations are taking hold of the operating end of the truck and bus transportation business. Apparently the days of the irresponsible operator are numbered. The interest taken in the meeting by representatives of the electric street-railways and the railroads reflects the strengthened position of automotive transportation. Two of the papers made it evident that gasoline-propelled rail-cars possess great economic advantage for roads operating light-traffic branches.

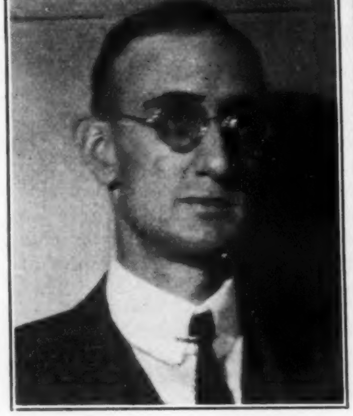
Attendance at the sessions was very satisfactory, the total registration being in excess of 200. This attendance included a large number of representative transportation men, many of whom came from other cities to hear the papers and discussions.

Judging by the comments heard around the several meetings, the Automotive Transportation Meeting papers won general approval. The discussions were active and produced many interesting additions to the material brought out in the papers. A majority of the papers read at the meeting are published in full in this issue of THE JOURNAL. Those that are not are abstracted in the news account of the meeting which follows. This account also reports the outstanding points raised in the several discussions.

MOTORBUS ENGINEERING INDICATIONS

Likely Trends of Development That Will Produce the Ultimate Vehicle

Six-wheel and tractor-trailer as well as so-called "articulated" types of motorbus, combinations of street-car and motorbus services, larger and better equipped motorbuses, acceleration requirements, powerplant, lighting, heating and ventilating are some of the many important phases of motorbus development that were presented and discussed at the



G. E. A. HALLETT

V. E. KEENAN

morning session held on Sept. 18, 1924, in the ballroom of the Hotel Pennsylvania, New York City. George E. A. Hallett was chairman.

STREET RAILWAY AND MOTORBUS SERVICE

Following the presentation of V. E. Keenan's paper on Public-Utility Experience with the Motorcoach, printed elsewhere in this issue of THE JOURNAL, the author answered R. E. Plimpton's question regarding the derivation of the flat costs by saying that the data given cover actual costs of motorbus operation for 1 year, all the buses being single-deck vehicles. D. J. Locke, of the Public Service Railway Co., Newark, N. J., stated his belief that the larger motorbus will necessitate longer headway intervals. Mr. Keenan admitted the truth of that probability but said that the 14 to 17-passenger motorbus has no truly economic field.

Mark A. Smith, of the Royal Motor Coach Co., Rahway, N. J., stated that one solution of making the small motorbus successful is to increase the center-to-center distance between the seats in territory where "standee" regulations are not enforced. With a 32-in. center-to-center distance between seats, 27 passengers can be accommodated, and room provided for standees. In territory in which standees are not permitted, the larger motorbus is needed.

MOTORBUS OPERATION AND MAINTENANCE

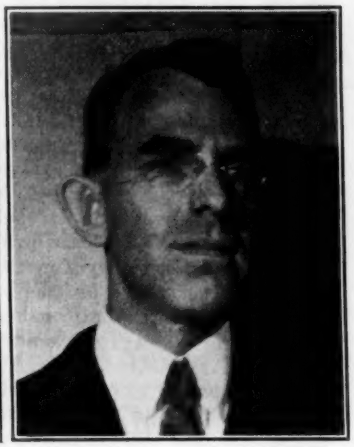
This subject was presented by J. B. Stewart, Jr.; his paper is printed in full in this issue of THE JOURNAL. F. C. Horner opened its discussion, saying that all motorbus development must withstand the acid test of practical service and that what will satisfy the public must be ascertained. In answer to some of his queries, he was told by Mr. Stewart that the ratio of one motorbus in reserve to each five in service had been found necessary, as a result of practical experience, to maintain maximum-load requirements; also, that the unit system of repair is used and that Mr. Stewart thinks it imperative that a motorbus receive its test in actual traffic service. Mr. Horner was insistent in questioning Mr. Keenan and Mr. Stewart regarding the relative merits of four-cylinder and six-cylinder engines for motorbus service, but neither author was ready to admit that the six-cylinder engine is desirable.

As a motorbus builder, Mark A. Smith said that it is time the industry sell motorbuses more as engineers than as salesmen. He cited passenger-haulage statistics for rail-

road and for motorbus operation in certain districts to indicate the great field the industry has for building motorbuses for the operating companies. It was said by L. H. Palmer, Vice-President and General Manager of the United Electric Railways Co., Baltimore, that he considers the 1 to 5 ratio of motorbus reserve high; the reserve in street-railway service is 10 to 12 per cent.

B. B. Bachman spoke regarding engine size and rear-axle ratios, or engine speed and vibration versus hill-climbing ability. He said that acceleration requirements for motorbuses make these subjects vital factors in profitable motorbus operation. He suggested possibilities of substituting electric transmission in cases where mechanical difficulties are at the minimum, discoursing also on the inaccessibility of parts and its bad effect on motorbus maintenance. Mr. Keenan doubled the necessity or desirability of electric transmission for motorbus usage.

F. C. Horner



D. J. Locke

The Six-Wheel Motorbus

Substantial reduction of motorbus depreciation by materially increasing the useful life of the vehicle is an important problem now facing the automotive engineer, according to A. F. Masury, vice-president and chief engineer of the International Motor Co., New York City, who presented a paper entitled Future Problems of Motorbus Engineering. Contrasting present motorbus life with that of street-cars, he finds a probable life of 4 or 5 years only for the former and 20 to 25 years for the average type of trolley-car. This, in the case of the bus, he says, is too short a period of usefulness and directly affects operating costs, since the increased cost of motorbus maintenance offsets its lower initial cost.

Demand for maximum comfort, safety and speed from the public and for economical operation from the operators has renewed interest in the six-wheel motorbus and given its design an impetus, although present four-wheel motorbuses of 25 to 30-passenger capacity have, and will continue to have, a very definite field and will not become obsolete due to replacement by other types. However, the exact placement of the line of demarcation between the four and the six-wheel types is a problem. Specification of maximum vehicle-weight per inch of tire width will regulate motor vehicles most logically for highway conservation, in Mr. Masury's opinion, other means being stated to be manifestly unfair, unscientific and detrimental to economic progress.

Design and location of the chassis units to permit adequate ground-clearance and low-hung floors is a perplexing matter. Assumptions of seating capacity, body dimensions and power needed come first; then, the determination of the wheelbase. For the six-wheel type, the last is either the distance between the front axle and the forward rear-axle or the distance between the front axle and a point midway between the two rear-axles; but Mr. Masury leaves this question open, as well as that of the proper ratio between the wheelbase and the distance between the two rear-axles, except that these axles should be as close to each other as possible to reduce axle side-slip to the minimum.

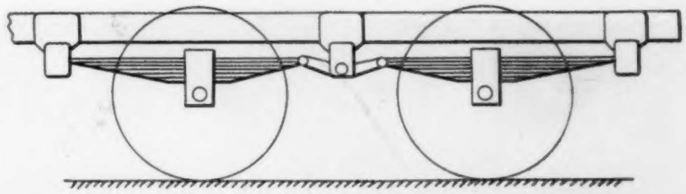


Fig. 1—Spring-Suspension Used on the Paris Six-Wheel Buses
These Vehicles Are Driven by the Middle Axle and the Steering Is Done by the Other Two. A Compensating-Beam Arrangement Is Located between Each Spring and the Suspension Requires a Fixed Distance between Each Rear-Axle, Thus Necessitating Steering More Than Two Wheels

Spring-suspension should consist of the simplest spring combination that will provide maximum flexibility. Numerous spring-combinations were illustrated, two being reproduced herewith. Fig. 1 shows the suspension used on the Paris six-wheel buses that are driven by the middle axle and are steered by the other two axles. It has a compensating-beam arrangement between each spring and requires a fixed distance between each rear-axle, which necessitates steering more than two wheels, but it is simple and extremely flexible. Fig. 2 shows the system adopted by the California Traction Co. It has six springs, three on each side; two are inverted semi-elliptic springs pivoted individually at the center and bolted directly to the axles at their ends. A third shorter and stiffer semi-elliptic spring connects this assembly to the frame in the conventional manner.

Two rear-axles permit smaller axle-units, provide increased ground-clearance, decrease over-all height and reduce individual unsprung weight, according to Mr. Masury. When the wheels of one axle roll over a bump, the rise of the spring weight is only one-half that occasioned in the conventional design, but the time required is the same; therefore, the velocity of drop of the sprung weight is halved. Since the impact force is $F = \frac{1}{2} M V^2$, the body reaction and stresses induced in this type are but one-quarter of those felt in the single-rear-axle type and this fundamental advantage of the dual rear-axle produces the increased good riding-quality attained.

Other questions on which opinion is divided are whether to drive with only one of the two rear-axles, using the other as a load-carrying element, to drive through all four rear wheels, to transmit power through the gears of the first axle to the second or to divide the power equally between each of the axles by using a power differential. The maximum universal-joint angle permissible with any spring and drive arrangement and the one that will permit the axles to maintain a fixed relation one to the other eliminates the angularity of the short drive-shaft between each axle.

Skidding is practically eliminated when braking all four rear wheels of a six-wheel motorbus, even on wet, greasy, smooth pavement; therefore, it is questionable if brakes on the front wheels also are needed. As the size and weight increase, servo mechanism becomes necessary; the question

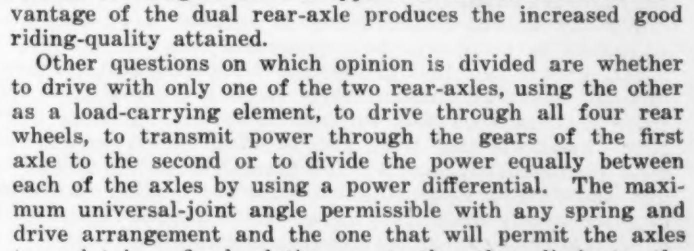


Fig. 2—System of Spring-Suspension Adopted by the California Traction Co.
Six Springs, Three on Each Side, Are Used in This Design. Two of the Springs Are of the Inverted Semi-Elliptic Type and Are Pivoted Individually at the Center and Bolted Directly to the Axles at Their Ends. This Assembly Is Connected to the Frame in the Conventional Manner by a Third Semi-Elliptic Spring That Is Shorter and Stiffer Than the Other Two

A. F. MASURY

L. H. PALMER

then is whether to cause it to operate a drive-shaft brake in conjunction with front-wheel brakes or to cause it to apply the wheel brakes only, reserving the drive-shaft unit for emergencies.

Steering must remain easy, even though the wheelbase increases. This may necessitate center-point steering, possibly having the axis of the king-pin in the plane of the wheel.

Mr. Masury said that the bore-and-stroke ratio of the engine must be chosen to comply with the accepted characteristics of a motorbus engine, but must also combine the maximum crankcase-front-axle clearance with a low over-all-height. He favors the four-cylinder rather than the six-cylinder engine for this service.

Frame construction presents the problem of striking a compromise between relative rigidity and excessive weight. A flexible frame demands a flexible body. The choice lies with the flexible type of motorbus chassis and body or the super-rigid assembly. Other problems relate to ventilation, heating, freedom from road dust, prevention of exhaust gases and engine compartment vapors from entering the body and the elimination of noise. Safety appliances that will apply the brakes automatically in case of accidental loss of control by the driver were suggested.

Mr. Masury said that greater manufacturing cost, increase of total weight and higher transmission losses constitute the price that must be paid for vehicles employing more than four wheels, but that these may be offset by the increase in good riding-quality, and by the greater capacity, tire-mileage and fuel-economy obtained. Future development also depends largely upon the progress made in road design and expansion of the areas traversed by suitable highways.

In the discussion that followed Mr. Masury's paper, W. P. Kennedy, president of the Kennedy Engineering Corporation, New York City, described briefly the design and construction of a tractor and semi-trailer type of motorbus in which the body portion is joined to the tractor portion by a cowl arrangement, thereby making it, in effect, an articulated vehicle. Its rear-axle steering-gear and cam provisions make steering of the trailer automatic with the steering of the tractor, and the driver need steer only the front wheels of the tractor. An advantage of this method is to shorten the turning-radius required otherwise.

Mr. Masury remarked that a disadvantage of the foregoing type of motorbus is its unconventionality and consequent failure to appeal to people on the basis of attractive appearance. He answered Chairman Hallett's query regarding upkeep by saying that the maintenance cost of a six-wheel motorbus is less than that of a four-wheel type, due to better traction and more even distribution of the strains on the parts during service. He cited an instance of trailer haulage of passengers in which a well-known automobile was used as a tractor for a 2600-lb. four-wheel trailer that carried people to and from a land development project near Miami, Fla., successfully.

On the subject of the amount of under-gather needed when dual tires are used on crowned roads, Maurice Walter said that a 2-deg. inclination of the wheels provides an average error of 1 deg., whereas this error frequently is as much as 3 deg. Mr. Masury mentioned tests of horse-drawn vehicles that had been made by Professor Kennerson at Providence, R. I., showing that under-gather did not reduce the amount of power required to pull them.

Mark A. Smith asked for information regarding tire size and weights carried by the tractor axle of the vehicle Mr. Kennedy described and was told that the load on this tractor's axle is not abnormal and therefore does not necessitate a special size of tire. In a general statement of desirable lines in which motorbus development might proceed, Mr. Smith spoke of minimizing maintenance costs and breakdowns. He said that designers are endeavoring to use units that have been proved out, but that it is difficult to specify such units. He told of a recent carnival near West Orange, N. J., that necessitated the transportation of many people over a road that included a maximum grade of 11 per cent. Twenty motor vehicles of 25 to 30-passenger capacity each were drafted for this service and eight of them could not climb over the hill, thus proving themselves unsuitable for work involving hill climbing.

Further, Mr. Smith mentioned concentration of parts as most desirable; that is, equipment cannot be mounted amidships on a motor vehicle unless extra shafts, stays and the like are also provided. He believes that the following of accepted lines of taxicab practice will prove advantageous and most satisfactory for motorcoach development, and advised concentration on the simplification and perfection of the chassis, clutch and brakes.

Speaking as a representative of the American Electric Railway Association, L. H. Palmer, stated emphatically that the number of passenger-miles rather than the number of passengers should be the basis for any comparisons between motorbus and street-railway performance; otherwise, all such comparisons are unfair. He believes the electric-railway organizations will continue to be the recognized passenger-transportation agencies. In reply, Mr. Masury said that, when the electric-railway companies make extensions, they do not extend their trackage, but use motorbuses, and that their problem now is the motorbus problem.

Alfred Reeves general manager of the National Automobile Chamber of Commerce, said that the public has become aroused over the passenger-transportation situation and is demanding improvement. He believes that the electric-railway organizations will continue to transport the people but that they will use motorbuses increasingly. Further, that they ought to take in the independent motorbus operators and manage passenger transportation for the best interests of the public.

Nearly 100 members and guests partook of the excellent luncheon served in the Hotel Pennsylvania after the conclusion of the morning session.

DESIGN, OPERATION, MAINTENANCE

Second Motorbus Session Hears Discussion Led by Howell, Bersie and Fielder

At the second motorbus session, held on Thursday afternoon, Sept. 18, at the Hotel Pennsylvania, the papers presented were prepared by F. D. Howell, vice-president of the Motor Transit Co., Los Angeles, on Some Notes on Automobile Stages in California; by Hugh G. Bersie, engineer, Haskelite Mfg. Corporation, Chicago, on Developments in Motorbus Design; and by R. E. Fielder, chief engineer, Fifth Avenue Coach Co., New York City, on a System of Control of Motorbus Maintenance. In the absence of Mr. Howell, his paper was read by R. E. Plimpton. A. J. Scaife presided.

The small ballroom of the hotel was well filled. Much interest was shown in the points developed by the speakers but as the reading of the papers consumed most of the available time little opportunity was afforded for discussion.

Operation in California

Mr. Howell described the rapid increase in popularity of motorbus transportation from the days of the "jitney" to the present railroad-coach-type vehicles used in through inter-city-service. He outlined the requirements of the three distinct classes of service, namely, the local-city, local-inter-city and through-intercity. The efforts of manufacturers to provide a chassis that will fulfil the needs of both passenger and freight service, he said, had not proved entirely satisfactory, for the requirements of motorbus service lie between the two. Brakes are deficient, wooden wheels are unsuitable, the tire problem should receive more attention, the tire products of all manufacturers should conform to the same standards of over-all dimensions and inner tubes should be made to fill the casings uninflated. The heaviest expenses of motorbus operation have been (*a*) the obsolescence of bodies to keep abreast of the times, (*b*) the reconstruction of stock chassis to conform to the needs of the stage-coach and (*c*) maintenance. The difficulties of obtaining proper equipment are so great, he said, that the operators may be forced to expand their plants to complete the assembling of the motorbuses. The paper is printed in full on p. 292 of this issue of The Journal.

Discussion of Operation

In opening the discussion, Mr. Horner emphasized the importance of getting a clear conception of the users' requirements; a more careful study of these requirements and of the comfort of the riding public would aid in finding the true answer to the future of the motorbus. All phases should be taken into consideration. He said that it is impossible to do all the things desired by the users. The greatest mistake that manufacturers have made is to endeavor to convert a merchandise carrier into a vehicle for carrying passengers.

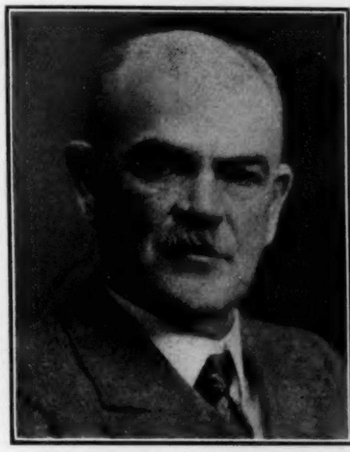
Chairman Scaife agreed with Mr. Horner. He added that the only thing to do is to get a composite picture of the whole situation. Some operators say that they cannot use the very things that others cannot do without. A careful study of the design of bodies should be made. Some vehicles carrying from 18 to 22 passengers, a load of about 4000 lb., weigh from 9000 to 11,000 lb., whereas some trucks weighing 10,000 lb. carry 18,000 lb. of merchandise.

On account of lack of time it was requested that those who desired to ask questions should write them on the question cards in order that they might be answered in a later issue of The Journal.

Motorbus Development

Motorbus development, in the opinion of Hugh G. Bersie, has been and will continue to be influenced largely by its two principal competitors, the passenger automobile and the street-car. As a transportation medium its future is entirely in the hands of the builders and the operators. At present the trend seems to be toward the pay-as-you-enter or street-car type. As a motorbus approaches a prospective passenger his impression of it is gained from its general appearance, and as he enters it this impression is made more favorable by low steps and floors, wide entrance-doors and aisles, ample head-room and knee-room, comfortable seats, good riding-qualities and effective ventilation, lighting and heating. Bright colors, stream-line effects in design and small amount of overhang add to the appearance.

The passenger's ease of entrance is increased by a low step and floor, which also decreases the time required in entering and leaving. A low floor may be secured by resting the flooring directly on a chassis frame of kick-up construction. Maple is the favored wood; this is laid lengthwise on cross-sills spaced from 18 to 24 in. apart. A covering of linoleum makes the floors gas-tight. Current practice favors the folding jack-knife type of door, from 28 to 30 in. wide. A saving of time in loading and unloading has the same effect as rapid acceleration and high speed. The higher the speed the lower will be the charge for wages of the platform men for the distance covered. Head-room of from 72 to 75 in. is essential. The use of Haskelite roofing supported with stanchions has enabled the Yellow Coach Mfg. Co. to increase the head-room between 2 and 3 in., besides making the ceiling more attractive and more easily kept clean and sanitary. Three stanchions are sufficient even when the load on the upper deck is 200 lb. per seat. Placing the seats back to back on certain types of motorbus has enabled the head-room to be increased. The seats usually are from 28 to 31 in. wide, the aisles from 13 to 19 in. wide and the distance from the front of one seat to the back of the next, or the knee-room, is from 10 to 11 in.



F. D. Howell

Hugh G. Bersie

Comfort and Safety

Short overhang makes for comfort and safety and the latter is enhanced by the use of tough, non-splintering ash for framing, rather than maple, which breaks with a long fracture. When Haskelite faced with steel, termed Plymetl, is used, the energy of impact, in case of collisions, is absorbed and damage to the framework and to passengers is prevented.

Very little warming is needed and this is supplied by small pipes connected with the exhaust. Loss of heat through the window glass is unavoidable but the waste through the roof and other parts can be prevented by the use of heat-insulating materials.

Ventilation is secured in some cases by ventilators placed in an arch-type roof, but a later method is by small ventilators termed louvers just above the windows. Lighting has been improved by using bulbs of greater candlepower and by making use of the reflecting power of the ceiling.

Profitable operation requires low maintenance-expense, and this can be secured only by the use of the best type of framing, well-made joints and easily replaceable parts. Standardization of parts, so successfully practised in the construction of the chassis of passenger automobiles, could be made use of to good advantage in reducing the cost and speeding up the delivery of motorbuses. The factors in body design that will affect the ultimate scope of motorbus transportation are the safety and comfort afforded to passengers.

Emergency Exit-Doors

The discussion that followed the reading of the paper had reference principally to the location of the emergency exit-door. Mr. Bersie maintained that the best place is on the left side at the rear. Chairman Scaife suggested that if the motorbus rolled over on its side the side door would either be inoperable or would be 7 ft. from the floor; that it would save cutting a hole in the roof if the door were placed at the rear in the center. Mr. Horine remarked that a center door at the rear would prohibit the carying of a spare tire; that if a motorbus were to roll over, the frame would be sprung to such an extent that the door could not be opened. Opening a window, he thought, would be simpler than cutting a hole in the roof.

Mr. Howard, referring to the time when he had been in

R. E. FIELDER

LAWRENCE G. SIRCOULOMB

charge of an emergency crew, said that the emergency doors could never be opened, no matter where they were placed; that they were not in condition to open. Besides, in emergencies passengers do not line up and wait for a door to be opened.

Mr. Fielder made the suggestion that all windows should be made large enough to be used in case of emergency.

Chairman Scaife stated that a standardization committee of the Society now had the matter of door widths, window heights and the like under consideration. He said that at present most windows are 20 in. wide and that a standard 22-in. pane of glass must be cut down to fit them.

Replying to the questions submitted on cards, Mr. Bersie said that the tendency is toward a 34 or 35-in. width of seat; in other words, toward a wide seat and narrow aisle. But a narrow aisle prevents quick loading and unloading. If a wide seat is adopted, the speed of loading and unloading is sacrificed to comfort. If seats are too narrow, large passengers will project into the aisle and block the passage-way; the effect is the same, so the seats might as well be made wide. Cross seats seem to be preferred to longitudinal ones.

Plymetl is employed not for the roof but for the floor and the side-panels. Deterioration of the body sills, caused by water dripping down when the windows are open, has been prevented by the use of a molding to drain the water from the sill. Another method is the drilling of small holes so that the water will drain out instead of collecting in a pocket. This slightly weakens the sill and the holes frequently become clogged with sediment and dirt.

Regarding the saving of weight, the use of a 5/8-in. instead of a 7/8-in. panel would mean a saving of about 30 per cent. Paneling would also save the amount of white lead used, sometimes as much as 100 lb., in making the roof waterproof.

REDUCTION OF BODY WEIGHT

Mr. Horner asserted that, although all seem to agree regarding the reduction of the weight of bodies, no one seems to know how to tell the body-builders to do it. The body-builders are of two classes, those that have come from the ranks of the street-car builders and those that have been wagon and truck builders. What is needed is a body that is light yet will withstand rough usage.

The Germans, said M. S. Cooper of the Associated Equipment Co., will not buy American motorbuses because they are too heavy. By using thin wood, they can build double-deck motorbuses that have less weight than American single-deck motorbuses. Mr. Horine called attention to the passenger-pullman airplane being built by W. B. Stout in Detroit. The entire shell, he said, is made of sheets of duralumin riveted together. The airplane can be lifted by one man without difficulty; its total weight is 485 lb. As the strains in an airplane are very great, to be durable an airplane must be very strong. Body-builders might profit by airplane construction. Motorbus bodies are built sufficiently stiff to be self-supporting, but as the frame under the body is also self-supporting unnecessary duplication exists. Truss duralumin construction, he thought, would probably accomplish more than the German basket-weave construction.

IMPORTANCE OF RECORDS

Motorbuses, to give continuous and rapid service, must have adequate maintenance. In the system of keeping the records of the Fifth Avenue Coach Co., as described in detail by R. E. Fielder, the first requirement is to know the mileage covered by each vehicle in a given period of time. This may be done either by measuring accurately each route and multiplying by the number of trips or by using recording instruments. Each of the four operating divisions of the company, he said, has a complete organization, which cares for approximately 100 revenue and non-revenue vehicles, the mechanics, each with an assistant, being responsible for the efficiency of some particular unit. In addition to the mechanical operating department, shops are necessary for the periodic overhauling of the chassis and the body. Special records are kept of the mileage of tires, and also of the number of times that the wheels are removed. Inasmuch as the cost of tires per mile varies from 1.0 to 2.5 cents, depending upon whether solid or pneumatic tires are used, and as the total mileage covered annually by 400 motorbuses is about 14,000,000, the importance of this record is obvious. The expense of maintenance and the depreciation account are inseparably linked: money saved on maintenance should be accumulated as depreciation reserve and, vice versa, the more money that is spent in maintenance, the longer will be the life of the vehicles.

VARIATION OF MAINTENANCE COSTS

Maintenance costs, Mr. Fielder said, vary in different localities, being affected by traffic conditions, topography, the type and capacity of the vehicles, the speed that is maintained, the size of the fleet and overhead expense. For the sake of simplicity, vehicles that go into service on a certain date are considered as a group, but, as particular units are repaired by the same men, working in special sections, the cost of maintaining the units is important and is obtained with the aid of unit change-slips. By referring to the mileage record of a vehicle the service rendered by a particular unit can be ascertained and the quality of the material checked. Cases of unusual trouble are noted and the causes are investigated. From the material requisitions, the amount of material consumed in a month can be allocated to the units and the divisions using it.

Two or more gasoline-filling and oiling stations are located within each garage, several motorbuses being able to enter at one time. While attendants are supplying gasoline, oil and water to the motorbus, the driver and the assistant night-foreman make a general inspection of the vehicle, paying particular attention to the steering-gear and levers, the springs and the brakes. This information, when recorded, is afterward used as a guide in checking the work done. In addition to this inspection, a weekly inspection of each major unit is made at night, while the motorbus is stored in the garage. The detailed information obtained is recorded on a general-overhaul sheet that shows the performance of the motorbus for approximately 2000 miles. When the mileage has reached this amount, the motorbus is sent to the shop for a general overhauling, which requires about 5 hr.

Each motorbus is swept out, and the windows, brasswork and hand-rails are cleaned every night. After a rainstorm the buses must be washed to remove mud; they are also given a general washing every few days.

COST OF GASOLINE AND OIL

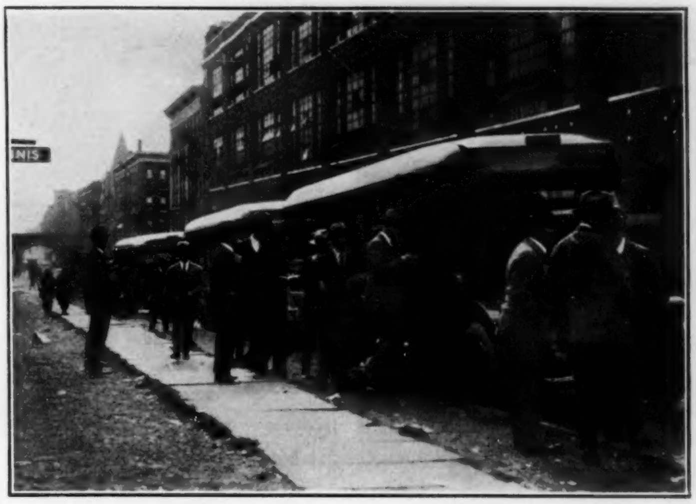
As the cost for gasoline is 3 cents per mile, or about $1,050 per year per vehicle, the total annual cost is $420,000. Checking the gasoline consumption involves measuring not only the quantities used continually by each vehicle but also the quantities in the storage tanks before and after the oil company has delivered its loads. A comparison of the gaso-

line used with the mileage traveled by each vehicle serves as a true indication of the condition of the engine and the ability of the driver.

Oil expense is about 0.16 cents per mile, or about $56 per engine; for 400 vehicles this amounts to about $22,400 per year.

A record of the involuntary delays for various causes is a key to the efficiency of the operating department. When delays occur frequently the cause is investigated and action taken to avoid further repetition. Weekly and monthly summaries show whether the responsibility for the delays is to be laid to operation, inspection, the quality of the material or deficiency of design. Comparison with previous corresponding periods gives an index of the efficiency of the organization. Non-revenue producing vehicles, such as snowplows and sand-trucks, are not overhauled periodically but are inspected as often as is necessary to make sure that they are in condition for immediate operation.

On account of the lateness of the hour and the fact that an opportunity would be afforded the following morning during the visit to the plant of the Fifth Avenue Coach Co. to ask questions and gather additional information, the meeting adjourned without the usual discussion.



BOARDING THE MOTORBUSES AT THE GARAGE OF THE FIFTH AVENUE COACH CO.
One of the Features of the Automotive Transportation Meeting Was an Inspection Trip That Covered the Garages and Shops of the Fifth Avenue Coach Co. and the Garage and Service-Station of R. H. Macy & Co.

INSPECTION OF PLANTS

Shops of Fifth Avenue Coach Co. and of R. H. Macy & Co., Inc., Visited

Whenever a major repair job becomes necessary on an important unit of a Fifth Avenue bus, the unit involved is removed from the bus and is immediately replaced by a serviceable unit taken from stock. The necessity of detaining the bus for a considerable period of time is thus avoided. In the case of an engine with a damaged connecting-rod, crankshaft, valve sleeve or other vital part, the engine after being removed from the chassis is disassembled, all parts being placed in trays provided for the purpose on a special movable stand. The parts are then taken on the stand to the cleaning room where they are thoroughly washed. The next step finds the unit at the inspection bench where all parts are thoroughly examined by the foreman to determine what is necessary in the way of repair or replacement. At the work bench that is situated beside the inspection bench, five specialists are stationed, and the engine passes through the hands of these men until the necessary repair work has been accomplished and the engine is completely reassembled.

It then passes to the dynamometer where tests are made to determine friction horsepower, power output and fuel consumption. During the dynamometer test it is possible to detect errors in the adjustment of pistons, crankshaft bearings and any other parts of the mechanism. Upon passing the dynamometer tests successfully, the complete unit is sent to the storeroom where it is held in readiness for withdrawal by the operating department.

The same general procedure as that outlined above is followed in the case of other major units of the bus chassis, this work being carried out at the 102nd Street shops of the Fifth Avenue Coach Co. In addition, considerable experimental and developmental work as well as the periodic overhauling of buses is carried on at this shop. Garage space for storage and for the general care of the buses is also here provided.

An opportunity to observe this plant in action was afforded a large number of members and guests on the morning of Sept. 19, following the presentation on the previous afternoon of an interesting paper by R. E. Fielder, chief engineer of the Fifth Avenue Coach Co., outlining its method of bus maintenance. After the inspection of the 102nd Street plant, the members were taken to the 132nd Street plant of this organization, where the construction and repair of bodies are carried on. Here the different stages of body construction could be observed and also the repair of bodies from the time they are removed from the chassis to the point where they receive a final coat of paint and are then attached to the chassis, ready for service. Of particular interest in this process was the use of wooden jigs during the construction of new bodies. The expeditious handling of the bodies by hoists was a notable feature. This plant also provides garage space and servicing facilities for a large number of buses. The Fifth Avenue Coach Co. maintains a well-organized system of inspection and testing which is largely responsible for efficient operation of its units.

Through the courtesy of R. H. Macy & Co., Inc., the members and guests were permitted to visit its garage and shops where the automotive equipment of this large department store is maintained and stored. A visit was also made to the package-delivery department of the store where the processes of sorting, conveying and loading were seen in operation.

Several of the members also took advantage of the invitation of the Motor Haulage Co. to visit its plant in Brooklyn, which was described in a paper presented at the Transportation Meeting by J. A. Hoffman.

Those who were fortunate enough to make the inspection trip described above were unanimous in their appreciation of the courtesies extended by the companies involved. The excursion was made more pleasant by the kindness of the Fifth Avenue Coach Co. which provided four buses for the transportation of the members.

MOTOR-TRANPORT PROGRESSIVENESS

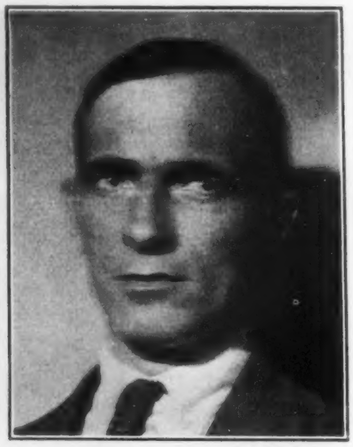
Headway Evident in Solving Perplexing Truck and Rail-Car Problems

Salient features of success in overcoming many of the obstacles incident to the development of organized motor-truck haulage, of practicable designs and usages of trailers and demountable bodies, and of satisfactory motor-rail-car service crowded the program presented at the Motor-Transport Session held in the afternoon of Sept. 19. A. J. Scaife acted as chairman and, in his opening remarks, said that the three essential queries concerning a motor truck relate to how much it costs, how much it will carry and how long it will last. He believes the first has to do with the builder of the vehicle, the second concerns both the builder and the operator and the third depends mainly upon the operator.

COMMERCIALIZED MOTOR-TRUCK HAULAGE

Essentials of a successful motor-truck-haulage organization were presented in comprehensive form by J. A. Hoffman and W. F. Banks of the Motor Haulage Co., New York City,

J. A. Hoffman



J. A. Evans

their papers being descriptive of the practices of the company they represent. The methods of this company in handling freight for the Long Island Railroad were related in some detail by J. A. Evans, assistant chief engineer of that railroad.

Plant, organization, kinds of haulage business and how obtained were included in Mr. Hoffman's description. Ten divisions of the business, such as movement of commodities from docks, of import consignments, of merchandise on long-distance and day-haulage bases, of package and other special services, were mentioned, the last being so-called contract work in which large fleets of motor vehicles are furnished to and operated for customers. The appeal for patronage is made on the basis of service and economy. Estimates are submitted when soliciting contracts and quotations of cost for the proposed service are based upon a thorough knowledge of the service required that has been obtained after a detailed investigation. Other features of the service include "surplus" and pick-up work and the furnishing of individual trucks and consequent reduction of idle truck-time for small businesses. Heavy insurance against public liability is carried.

Mr. Evans said that the Long Island Railroad has a terminal on Manhattan Island for coastwise receipt and delivery and for freight originating in the department stores; one in Long Island City, where all railroads entering New York City, except the New York, New Haven & Hartford, interchange freight with the Long Island Railroad; one in Bushwick, an outlying district of Brooklyn, and a fourth at Flatbush Avenue, Brooklyn. The three terminals on Long Island also serve the industrial development in their respective territories.

Prior to motor-truck haulage, each of these terminals loaded cars to various eastern branches of the Long Island Railroad, and many cars were not fully loaded. Now, freight from the three Long Island terminals for the Whitestone and Port Washington branches, 10 and 20 miles in length respectively, is carried by motor trucks owned and operated by the Motor Haulage Co.

Flatbush Avenue freight for Port Washington, for instance, is loaded on a semi-trailer and taken to Long Island City for concentration. There, a "zone car" is loaded. At its destination, it is met by a motor truck, which then delivers the freight eastwardly. Two motor trucks operate along the Whitestone and the Port Washington branches in a "peddle-freight" service. Tractors and trailers operate within the Long Island terminals district for inter-terminal service.

Service is the only thing Mr. Banks' company has to sell. Its equipment consists of motor vehicles, garages, garage equipment and maintenance facilities. Slides were used to illustrate the different types of vehicle, the use of sectional protective tarpaulins and other special equipment. Different types of van and "stake"-body trucks, tractor-trailer and armored-cab vehicles are included. The tendency is to use a body 8 ft. wide.

Features of the garages include doors 14 ft. wide, floor space free from columns, large floor-area, interior curbs on each side against which to back the rear wheels of trucks and thus stop the vehicle before the rear end can hit the wall, pilot lights for ordinary use and flood lights for emergencies.

Mr. Banks emphasized the necessity for having a thorough plan of maintenance in such a business. Its basis is standardization. The spare-unit-replacement plan is used. Inspection is very systematic and competent, by men who have had previous experience on equipment of a similar type. A reserve truck is sent out when a truck breaks down on the road. Time records of every operation are kept very accurately. "Delay" is considered the most important word on a driver's report, and he knows it. The repair shop has adequate appliances, including a traveling crane; and a rigid routine-system is maintained in it.

Control has for its basis a proper cost system, completely in accord with the general accounting system. Mr. Banks hinted at the great risk involved when he said that it is no joke to, figuratively, "kiss a $6,000 truck goodbye in the morning, hoping it will come back safely that night." But the operating organization consists of a superintendent, a dispatcher, competent foremen and drivers, all of whom have been selected carefully, well trained and encouraged by considerate treatment to render conscientious service, and thus the best service possible under any given set of conditions is made available.

Motor-Truck Trailers and Demountable Bodies

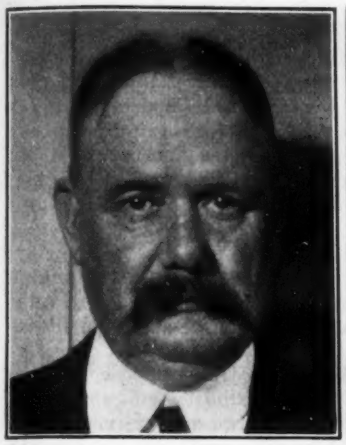
In commenting upon H. W. Howard's paper on the above subject, which is printed in this issue of The Journal, M. C. Horine acknowledged it to be a very complete presentation of the case for the semi-trailer, but thought it was somewhat overdrawn. He challenged Mr. Howard's statement:

> Large-tonnage trucks make for a low ton-mile cost, but injure the roads. The tractor-truck, semi-trailer and other trailer combinations handle volume tonnage at a still lower ton-mile cost without injury to the roads

saying that politicians have charged the heavy truck with destroying the roads to shift the blame for the untimely destruction of poorly built highways and to justify oppressive and discriminatory taxation of certain classes of citizens. Also, that railroads had used this argument in an attempt to stifle what they erroneously have regarded as competition with their service, and so had associations of passenger-car owners who were seeking the maximum mileage of light-surface roads for touring usage. Mr. Horine said that, although the bureau of public roads, the Motor Transport Corps and several of the engineering authorities in our universities have made research investigations for the last 5 years to ascertain the facts, no one competent to pass upon the matter had come forward either to confirm or to deny the allegation.

Regarding Mr. Howard's statement that "when a truck with four-wheel trailer is used, the truck naturally must stand idle while it receives its load," Mr. Horine said that, where four-wheel trailers are used, they are loaded and unloaded in the absence of the tractor exactly as in the case of the semi-trailer to a very great extent. He feels that the semi-trailer is in greater danger of failure to receive the recognition it deserves from its friends than from its enemies and believes no more reason exists for comparing motor-truck haulage and semi-trailer haulage than for making comparisons between railroad transport and motor-truck transport, because each has its field. All a tractor semi-trailer does, said Mr. Horine, is to provide a larger load-carrying vehicle for the same amount of tractive effort, equipped with two additional wheels; further, the sphere of operation for the semi-trailer is distinct from that of the motor truck.

In reply to Mr. Horine, attention was called by Mr. Howard to the fact that he referred to the "development" of the semi-trailer and of the four-wheel trailer in making com-



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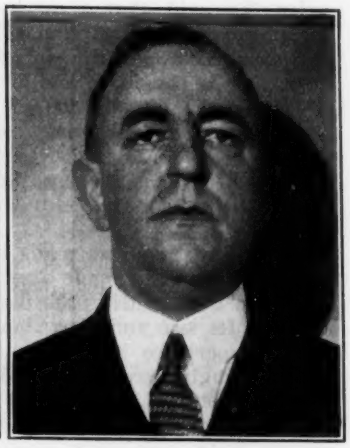


H. W. Howard

parisons. He did not refer to impact, he said, nor to the factors of weight and speed, in mentioning injury to roads, but rather to the spreading out of the weight of the load over a greater area of road surface, thereby lessening the detrimental effects, having reference exclusively to the hard-surface roads on which it is the road foundation that fails.

Mr. Howard cited the opinions of highway experts that, if a weight is applied at a given point on a road surface, a circular area of the road foundation having a 7 to 8-ft. radius from that point as a center will be affected. To space the weights 7 to 8 ft. apart, as is accomplished when the tractor semi-trailer is used, affords less chance for the weight to injure the road foundation and thus cause a breakdown of the road surface.

Interesting motion pictures were exhibited of the specially designed motor truck, equipped with demountable bodies, that is described in Mr. Howard's paper. The complete cycle of its operations of loading, hauling and unloading sugarcane on a sugar plantation in Cuba was depicted.

Motor Rail-Cars

This subject was treated by J. W. Cain, whose paper is printed elsewhere in this issue of The Journal. In the absence of Mr. Cain, the paper was read by F. C. Horner, who prefaced his reading by saying that Mr. Cain probably represents the railroads that comprise the largest field for the use of motor rail-cars. Further, that the large railroad systems may, later on, find ways and means to use motor rail-cars to greater advantage than they have in the past, because of the result of careful investigation and for the reason that the automotive industry will be able to develop motor rail-cars that will meet railroad requirements better.

Discussion of this paper was omitted because of Mr. Cain's inability to be present, but C. O. Guernsey of the J. G. Brill Co., Philadelphia, responded to Chairman Scaife's invitation to make remarks.

In reference to the table of operating costs in the paper, Mr. Guernsey said he doubts if these costs can be obtained generally. The railroad responsible for the basic data operates in a territory in which fuel costs are very low and, because it is a short-line railroad, can pay less than standard wage-rates. Such costs always vary, depending upon conditions, but an average of costs for a motor rail-car of the size and weight described by Mr. Cain, for the United States, indicates that a fair cost for short-line operation is 21 or 22 cents per car-mile. On a trunk-line railroad, the cost would be from 25 to 30 cents per car-mile.

Although he acknowledged that existing powerplant capacity and means of transmission do not permit much increase of power over that already in use, Mr. Guernsey is sure that the ultimate of power has not yet been attained and believes that specially designed clutches, transmissions, propeller-shafts, gearing, bearings and the like can be developed that will utilize any amount of power within reason. He agrees with Mr. Cain that both hydraulic and electric transmissions have decided advantages for large units.

JOINT MEETING WITH RAILROAD CLUB

Store-Door Delivery in London and Gasoline Cars on Branch Lines the Topics

On Friday evening, Sept. 19, a joint meeting of the New York Railroad Club and the Society was held in the Engineering Societies Building, New York City. F. T. Dickerson, president of the New York Railroad Club, presided. The speakers of the evening were James Paterson, director of Carter, Paterson & Co., Ltd., who addressed the meeting on the subject of British motor shipping methods, and W. L. Bean, assistant mechanical manager of the New York, New Haven & Hartford Railroad, whose subject was Gasoline Railroad-Cars for Branch Lines.

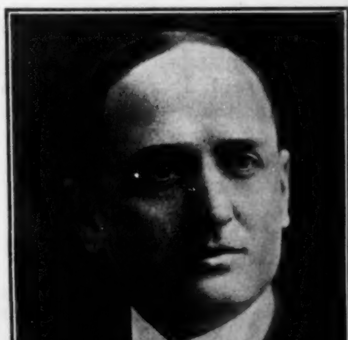
In introducing Mr. Paterson, President Dickerson referred to his company as "a firm that for a century past has been engaged in parcels and goods deliveries and is by far the largest company engaged in this work in Great Britain."

Mr. Paterson first outlined the conditions existing in the British metropolis and compared them in a general way with those in this country, insofar as his limited visit here had enabled him to do so. His paper, which covers such subjects as shipping and rail facilities in 4000 sq. miles, methods of delivery employed by his firm, freight rates charged by the railroads, the personnel of his organization, the types of transfer truck and their work, is printed in full elsewhere in this issue of The Journal.

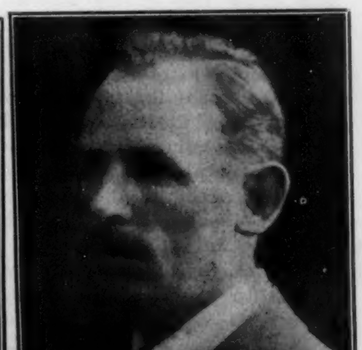
Use of Motor Trucks in Suburban New York

In opening the discussion of Mr. Paterson's paper, F. E. Williamson, of the New York Central Railroad, said that prior to 3 or 4 years ago trucks were not utilized much but that recently considerable experimenting had been done. Way-trains, he said, had been discontinued south of Croton and North White Plains, distances of about 25 and 30 miles, respectively. The freight for that territory originating in New York City or in the West is being consolidated at Yonkers and there sorted out for various truck points These trucks run to different points on the route, discharging freight on the way out, picking up westbound freight on the return trip and bringing it back to Yonkers, where it is consolidated into through-cars for destinations or for break-up points at some distance. This not only saves a little money but avoids interference by way-trains with through-traffic on the main line.

Trucks, he said, had also been used in connection with lighterage service in New York City. Practically all coastwise freight on the Manhattan side of the Hudson River is transferred direct to coastwise lines, in lieu of lighterage. The advantage lies in the freeing of lighterage terminals, more expeditious delivery, and the fact that a tug and lighter need not be used to handle small shipments. The



W. L. Bean



James Paterson

Erie Railroad, he said, has adopted the practice of transferring freight from its New Jersey yards by semi-trailers to Manhattan Island and there delivering it to inland stations or, by arrangement with the trucking company, at the store doors.

Store-Door Delivery in New York City

Store-door delivery, he continued, had not worked out very satisfactorily on the New York Central. The difficulty is that many persons to whom freight is consigned have no place to which it can be delivered. Some of them have nothing but a telephone.

Among the additional points brought out by Mr. Paterson's replies to Mr. Williamson's questions were the following: The lighters in use in the Port of London range in capacity from 7 to 150 tons. They are propelled by tugs. One tug frequently has several small lighters in tow. The congestion in London, Mr. Paterson said, is not so great as to interfere with delivery by trucks. He could not compare it with that of New York City, for he had not been here long enough. His observations caused him to think that the congestion in New York City is confined largely to the lower part of the city. In London the traffic is more spread out.

Delivery and pick-up, he said, are made during the working hours, but the transferring of merchandise from one point to another is done after hours when the streets are empty. In shipping a package from Edinburgh to Croydon, a suburb of London, for example, the package would go by way of London. If the shipper paid a collection and delivery rate from Edinburgh to Croydon, the package would be delivered at Croydon. If a trucking company instead of the railroad made the delivery at Croydon, it would be entitled only to a rebate amounting to the cost to the railroad of making the delivery from London. He said that carload shipments are trucked as well as small packages.

Control of Cartage

F. C. Horner, inquiring regarding the control of cartage, was answered by the statement that the whereabouts of vehicles is known and that they can be diverted on short notice, in case more than a load of freight should be encountered by any van on its route. Regarding the relative amounts of freight carried on the outgoing and the incoming trips, Mr. Paterson said that for every four trucks that went out about three returned with loads, but that in shipments to points like Brighton, the traffic is almost all in one direction in the spring and in the reverse direction in the fall.

Trucks are utilized up to a radius of about 50 miles; beyond that railroad service is cheaper. As a rule, he said, stores in London desire quick delivery rather than advertising. About 490,000 window call-cards are now in use. Trailers are simply four-wheel drays adapted to carry the same bodies that fit on the 4-ton trucks so that a truck can draw two bodies instead of one. Gasoline trucks are depreciated on the basis of 7 years; electric trucks, on 11 years. He added that after that point had been reached they hoped to make a profit, if they continued to use them.

The charge for electric power, he said, is about 2 cents per kw-hr., but that to get that figure the user must agree to take the current only at the times when it is to the advantage of the power-house that it should be taken.

With regard to the replacement of horses by trucks, Mr. Paterson said that after the war they had about 2000 horses; that they began to replace them at the rate of one truck for every four horses; that they bought over 300 trucks to replace the horses, but that they still had 2000 horses.

Gasoline Railroad Cars

W. L. Bean then described the experiences of the New Haven Railroad with gasoline railroad cars on its branch lines. The paper is printed in full on p. 306 of this issue of The Journal.

Considering first the factors necessary to successful operation, he said that they include (*a*) the horsepower of the powerplant in relation to the car-speed, weight, grades, curvature and operating schedule; (*b*) the type of transmission; (*c*) a consideration of single versus double-end control; (*d*) the distribution of the available floor-space; (*e*) the materials of construction; (*f*) the design of the car frame, body and trucks to give the maximum strength; (*g*) the heating, signaling, lighting, ventilation and braking, and (*h*) the advantages and disadvantages of multiple-unit control.

The suggestion was made that, with a view to economy, the body should be made as short as possible and the engine placed in a hood after the manner of the conventional automobile. Its size and type should be given careful consideration. Experience has shown, Mr. Bean said, that the six-cylinder engine seems best adapted to this purpose because of its quietness, smoothness and flexibllity of operation. Its size should be ample to give a large power-reserve, to ensure long life, low maintenance cost and adequate dependability.

In estimating the power required, allowance must be made for the power required to operate the auxiliaries, such as the blower, air-compressor, generator and pumps, and also for the loss of power involved in transmitting the power from the engine flywheel to the rails. The efficiency of the hydraulic transmission-system, he said, seemed to be about 69 per cent; that of the gasoline-electric type, about 72 per cent, and that of the geared car, about 80 per cent.

Transmission systems of the change-gear-propeller-shaft type, he pointed out, continue to be the most popular because of their low cost, light weight, simplicity and dependability. The simpler systems find the most favor among railroad men. The gasoline-electric type shows promise where the size, weight and power make gear-shifting difficult or where double-end or multiple-unit control is desirable. These systems, however, cost from $10,000 to $12,000 more than the change-gear-propeller-shaft systems of the same capacity.

The Tractive Factor

In opening the discussion of Mr. Bean's paper, Charles O. Guernsey emphasized the importance of light weight in design, saying that, for every ton that is carried, about 30 lb. of tractive effort must be added to the top gears. To the list of essentials enumerated by Mr. Bean he would add another, namely, that at least 50 per cent of the weight should be on the drivers. He took issue with Mr. Bean's method of comparing the form of cars and said that to determine the true power-factor, the weight and the speed should be taken into account. He presented a chart based on the tractive factor, that is, the tractive effort delivered at the rails divided by the weight of the car in tons. He maintained that by having several equally efficient driving-ratios high efficiency can be obtained with different speeds and grades.

Past-President Manly declared that Mr. Bean is the first railroad man he had ever heard mention the great value of alloy-steels in reducing weight. He believed that this feature would be of as great benefit to the railroad industry as it had been to the automobile industry. He thought that the figure given by Mr. Bean for the efficiency of hydraulic transmission was entirely too low; in some tests made in 1909, on cars equipped with hydraulic gears, he had obtained an efficiency of about 80 per cent. These cars were small, having about 50 hp. In the matter of acceleration, the hydraulic transmission, he said, gives a much higher rate than either gasoline-electric transmission or the clutch arrangement; he had been able to get an average speed of 15 m.p.h. when making 20 stops per mile.

DETROITERS OPEN THE SEASON

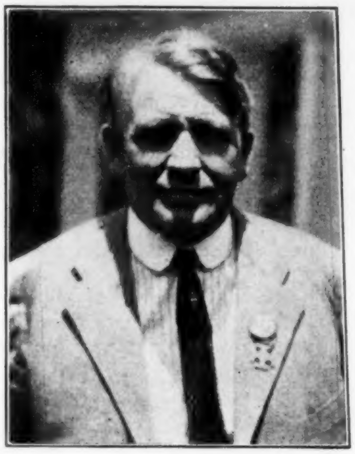
Putting aside engineering and business cares temporarily, the members of the Detroit Section gathered at the Detroit Boat Club on the evening of Sept. 10 and opened the fall season with an informal social dinner dance. Close to 100

members and ladies attended. One bystander remarked that the Detroiters were keeping in trim for the Carnival of the Society which will be held in that city on Jan. 21.

Governor Alex Groesbeck of Michigan and other prominent speakers will be featured on the Detroit Section program the evening of Oct. 9, when the engineering problems encountered in fitting highways to motor traffic will be discussed. The Detroit Section meetings are all held in the General Motors Building and are preceded by an informal get-together dinner at 6:30 p. m. The meetings start promptly at 8 o'clock.

DUESENBERG RELATES EXPERIENCES

Supercharger and Other Racing-Car Features Discussed Before Dayton Section



FREDERICK S. DUESENBERG

Four points were mentioned by Frederick S. Duesenberg, in his address before the Sept. 10 meeting of the Dayton Section, as being of the utmost importance in the design of successful high-speed engines for racing-cars. They were (*a*) reciprocating parts must be light, (*b*) sufficient valve-area and cooling-space must be allowed, (*c*) combustion-chambers must be small to permit rapid and complete combustion and (*d*) special spark-plugs must be provided to withstand extremely high temperatures. Mr. Duesenberg stated that, although the development of racing-cars has brought forth considerable valuable information concerning automobile design in general, the racing-cars themselves offer comparatively little in the way of detail that can safely be transplanted directly into passenger-car practices. This situation arises from the great difference in the characteristic requirements of the two classes of vehicle. Racing engines, for example, must be designed to render their best performance at high speeds, whereas the engines for passenger cars must perform best at comparatively low speeds. In the course of his address Mr. Duesenberg gave many interesting reminiscences of his racing experience and presented details concerning features that have been the basis of his success in the racing-car field.

ENGINES FOR RACING

The combustion-chamber form is perhaps the most important element of the engines intended for racing purposes. The combustion-chamber must be designed with great care and should be small enough to permit the charge to burn rapidly and completely. With a two-valve engine and a spherically shaped head, it was found possible to get better combustion than with a four-valve engine and a somewhat irregularly shaped head. In the latter case higher compression was required for equivalent performance. In the recent engines a compression pressure of 140 lb. per sq. in. at high speed has been used; this pressure drops as the speed is reduced.

Tungsten and silchrome valves have been found satisfactory. The valve-seats in the Duesenberg racing engine are ⅛ in. wide and the angle 30 deg. Changing the angle to 45 deg. was said to have caused a decrease of between 4 and 6 m.p.h. in speed attainable in a test. The camshaft had been designed to give the same opening with the 45-deg. seat as with the 30-deg. seat. The overhead camshaft was recommended as being superior to rocker-arm valve-action on account of decreased trouble from both valves and springs.

Pistons are made as light as possible. Three rings are used with better results than can be obtained with fewer rings. Piston speeds of from 2700 to 3000 ft. per min. have been found very satisfactory.

Connecting-rod breakage occasioned in the past by too light construction and poor steel has been largely obviated by greater care in design and improvement in the quality and uniformity of the steel. An interesting account of the development of a roller-bearing rod was given, and also a report of rod breakage resulting from an apparently insignificant error, the omission of a small fillet at the big end of the forging.

Very rigid crankshafts were recommended on account of the greater smoothness of running that characterizes their use.

Castor oil in the crankcase was said to be superior to

Schedule of Sections Meetings

OCTOBER

2—INDIANA SECTION—Governmental Research Activities in the Automotive Field—A. W. S. Herrington

8—MILWAUKEE SECTION (Racine, Wis.)—Springs—Louis Monk; Tires—L. J. D. Healy
Plant Inspection in the morning; Golf Tournament in the afternoon; dinner and meeting in the evening

8—NEW ENGLAND SECTION (Boston)—Development of the Hyde Fulcrum Spring

14—PENNSYLVANIA SECTION—The Traffic Problem—George Graham

14—BUFFALO SECTION—Steering-Gear Stability—James E. Hale

16—DETROIT SECTION—Changing Horse and Buggy Roads to Fit the Automobile—Col. S. D. Waldon; Governor Alex Grosbeck of Michigan

16—METROPOLITAN SECTION—The Merchandising of Replacement Parts—General symposium

17—CHICAGO SECTION—Development of Modern Racing Cars and Engines—Fred S. Duesenberg

20—CLEVELAND SECTION—Trends of European Design—Prof. C. A. Norman

22—NEW ENGLAND SECTION (Springfield, Mass.)—Operation of the United States Air Mail Service

NOVEMBER

4—BUFFALO SECTION—Fatigue of Metals

12—DAYTON SECTION—The Automobile from the Insurance Underwriters' Standpoint

13—INDIANA SECTION—Flow of Heat in Pistons—H. A. Huebotter

mineral oil on account of decreased dilution troubles. This advantage was believed to more than offset the disadvantage of the slight loss in available power that was said to result from the use of this oil. Cooling of the oil is accomplished satisfactorily by circulation of a volume of 5 gal. through a tank.

It has been found that spark-plugs give better service if the full-size hole does not extend entirely through the head. In recent designs communication between the combustion space and the plug is effected through a reduction of the lower part of the hole to an opening ¼-in. in diameter. With this arrangement it has been found possible to have higher compression-pressures with much less plug trouble from heating.

Superchargers

The supercharger as applied to engines for racing serves, first, to send into the cylinders an increased amount of combustible mixture and, second, to break up the fuel more completely than is possible with the carbureter alone. Mr. Duesenberg felt that the latter function should make the device attractive for adoption on passenger cars, for by its use the low-speed operating characteristics could probably be improved. The question of limited piston displacement that makes the supercharger doubly advantageous on engines for racing does not enter as such an important factor in the case of passenger cars. It has been found that better acceleration and general engine performance are attainable with the supercharger than without it; power can be gained with the greater possible spark-advance, a 42 to 45-deg. advance being used in the supercharged Duesenberg at the maximum speed. With the supercharger it is possible to operate satisfactorily with a greater variation in the timing of both the ignition and the valves. It was also reported that the carbureter seems to be less sensitive when the supercharger is in action.

The most practical compression-ratio without the supercharger was said to be 7 or 7¼ to 1. With the supercharger a ratio of 6 to 1 may be used. The action of the supercharger, however, makes this equivalent approximately to an 8 to 1 compression-ratio.

Chassis

Mr. Duesenberg believed that as much unsprung-weight as possible should be removed from the rear of the car. The wheels hold the ground better with a light rear-axle than with a heavy one. Better car performance can be obtained by the reduction of unsprung weight, and the riding-qualities of both racing and passenger cars can be improved by properly proportioning the sprung to unsprung weight ratio. Shock-absorbers adjusted for passenger cars are ordinarily ill suited to use on racing-cars, the latter requiring very stiff action.

The springs of the Duesenberg racing-cars have been lengthened to approximately two-third the length of the springs used upon the passenger cars of the same manufacture. It has been found advantageous to use a large number of thin, flexible leaves rather than a smaller number thick and comparatively stiff ones. Rubber spring-shackles were reported to offer considerable promise.

Tires, it was said, are limiting factors on the speed of racing-cars. Owing to the great improvement in both design and construction, that the past few years have witnessed, racers can now place greater confidence in their tires under very severe conditions of service. Tire and wheel balance are extremely important in high-speed work and great care must be exercised in bringing about as nearly perfect balance as is possible of attainment. Traction and speed are bound to suffer when these problems of balance are not satisfactorily solved. The choice of tires of proper size is important. In tests on Duesenberg racers the 5-in. tires were found to be superior to 4½-in. tires. Less slippage and better cushioning were noted with the large sizes.

The following miscellaneous points were covered by the speaker:

The rigidity of a steel frame of given weight has been tripled in a duralumin frame of equivalent weight.

On account of the weight requirements of racing-cars, many parts that are ordinarily cast should be made from sheet steel with welded joints.

Cars can safely be made lighter if balloon tires are used.

Fatigue failures are most prevalent in axle shafts, valves and valve-springs.

Hydraulic brakes have the advantage of equalization.

Fabric universal-joints have given very satisfactory results and have points of superiority over the metal joints.

Steering-gears for racing-cars should have no lost motion. The front-wheel drive possesses no great advantage over that on the rear. Mr. Duesenberg felt that troubles from tire slippage would be increased by use of the former.

A racing-car should have a normal life of from 5 to 8 years.

For dirt-track racing the wheelbase is usually from 88 to 96 in.; for board-track racing, from 96 to 105 in.

At the Indianapolis races the 122-cu. in. Duesenberg averaged 13 miles per gal. of fuel.

A four-cylinder engine exhibits less friction than an eight, but the reciprocating parts on the eight are lighter, and greater efficiency can be obtained; the eight-cylinder engine can be operated at higher speeds.

Racing-cars formerly having one carbureter for each cylinder were wasteful of fuel. Economy should be one of the recognized elements in racing.

Two carbureters on an eight-cylinder engine give better and more economical operation than one.

Dual ignition is recommended on account of the advantage of having a spare system in cases of emergency.

The Season's Program

Before introducing the speaker whose address is reported above, Chairman Asire announced the arrangements for a program of eight Section meetings to be held during the coming months. He also spoke of activities of the committee in connection with the award of the Wright Brothers medal. Twenty-five hundred copies of the announcement of this award have been mailed to all parts of the world, and it is anticipated that a number of contestants will soon enter the competition. Appreciation was expressed for the assistance already extended by the Air Service, the press and other organizations.

The meeting reported above was attended by 200 members of the Dayton section and guests. Preceding the meeting, an excellent dinner was served at the Engineers' Club to about 80 persons.

TAXI DEVELOPMENT DESCRIBED

Chicago Section Hears Paul Geyser and Visits Yellow Cab Factory

As the result of a pilgrimage to the birthplace of the vivid-hued Yellow Cab, some 125 members of the Chicago Section are able to explain how this sturdy successor to Dobbin's hack can withstand the abuse it receives at the hands of the average cab driver. They were also shown the fabrication of the Yellow Coach, mass transport companion to the smaller metered vehicle. Paul Geyser and G. A. Green proved to be genial hosts and won the praise of all present by their interesting talks on the highly specialized cab and motorbus industries.

Mr. Geyser outlined briefly the history of the taxicab industry from its beginning in 1911. At that time he was charged with the operation of a fleet of 150 cabs embracing 22 different makes of passenger-car chassis, six of them foreign. It soon became apparent that taxicab service was too rigorous for even the best of the passenger-car chassis and a specialized vehicle was designed based on an analysis of the company's records of service failures. The first of

CHICAGO SECTION VISITS THE YELLOW CAB FACTORY
On Sept. 19 This Section Opened Its Season by Spending the Morning Learning How the Familiar Yellow Cab Is Built. After Being Entertained at Luncheon by the Yellow Cab Mfg. Co. at the Factory, the Members Relaxed in the Afternoon on an Adjacent Golf Course Until Rain Interfered

these special cabs was put in service in Chicago in 1912. About the year 1915, the first step was taken to develop smaller, more economical and more comfortable taxicabs. From this date the progress of the taxicab has been a rapid one until, in 1923, over 2000 cabs were operated by the Yellow Cab Co. in Chicago alone, these cabs traveling an aggregate of 89,000,000 miles. To date in 1924, the Chicago fleet has traveled an aggregate of 105,000,000 miles, has burned 7,350,000 gal. of fuel and worn out over 20,000 tires. Excluding accidents, the cost of mechanical maintenance for this fleet has been less than 1 cent per mile.

A goodly portion of the credit for the development of the taxicab to its present efficient state was accredited by Mr. Geyser to the indispensable service rendered by the operating company. The perfection of taxicab design has been largely an operator's problem. The part that the engineer must play comes in the intelligent analysis of what the operator wants and must have. As an illustration of the importance of fitting the cab to the service expected by the operator, Mr. Geyser cited the simple case of moving the spare wheel rearward an amount sufficient to enable the car-washer to wash between the wheel and the body panel without removing the spare wheel. This change, requested by the operating company, effected an actual saving of $21,000 per year.

WEATHER MAN PIQUED AT AFFRONT

Taliaferro Milton, Chicago Section's supervisor of diversion, made a serious tactical error when he failed to invite the local weather prophet to participate in the golf tournament that followed the Yellow Cab visit. Soon after the first ball was teed off, gentle showers turned to a steady downpour that tested the enthusiasm of the field and eliminated all but those hardy hitters who had an eye on the prizes or carried the responsibility of defending wagers that had been made in a boastful spirit. It is reported that C. H. Roth and R. E. Wilson led the way home and captured the principal prizes. Walter Buettner, who has read all the books on golf and taken primary and college courses in the art, contented himself with sharing Milton's task of cheer-leader.

BETTER MOTORBUS ILLUMINATION

Practical Recommendations for Its Accomplishment Made at New England Meeting

Poorly lighted motorbuses will fast disappear from the highways if the practical suggestions given by A. C. Roy in his paper before the New England Section on Sept. 17 are adopted. Mr. Roy, who is connected with the Edison Lamp Works of the General Electric Co., told how that organization had conducted extensive investigations of motorbus lighting and found the following conditions prevailing: Six inefficient enclosing dome fixtures, generally in need of cleaning and usually with one inoperative due to a burnt-out or missing lamp. Two or 4-cp. lamps of inferior quality were used in the dome fixtures. Walls and ceiling were finished in dull colors. The wires were too small to carry the lighting load without excessive drop in voltage and the batteries had inadequate capacity. It was found that only 59 per cent of the buses had all dome lamps lighted. Illumination measurements in the buses tested indicated that 29.4 per cent of the buses had foot-candle intensities in the reading plane ranging from 0.01 to 0.10; that 68.7 per cent had from 0.10 to 1.00 and 1.9 per cent had from 1.00 to 3.00. The average intensity for all buses tested was 0.25 foot-candles. Nine styles of fixtures were noted, two being reflectors and seven enclosing units. Preference seemed to be given to one rather inefficient type. The only reason so far as could be determined, for using that particular fixture was that it could be purchased for less than the others.

An analysis of the problem indicated that it should be studied with the object of determining the minimum light-intensity required:

(1) For safety to the passengers upon entering or leaving the bus
(2) To prevent eye strain in case the passengers choose to read as they do on trolley-cars
(3) To secure the maximum advertising value from the ad cards
(4) To create a cheerful and inviting atmosphere within the bus which in turn would tend to create the riding habit

STEP-LIGHTS FACILITATE BUS LOADING

Actual stop-watch checks were made of the time to receive and discharge passengers on various runs in Newark, N. J., when buses were fitted with and without step-lights. These tests showed that the time taken to load a bus without a step-light was actually 11.4 per cent greater than when one was provided. Also, it was found that 14.8 per cent longer time was required to unload the buses not equipped with a good step-light. In providing a step-light, therefore, loading and unloading time is reduced and safety to the passengers is increased.

Eye-strain in motorbuses is caused by three conditions: insufficient light, glare and spotted illumination. It was found that due to the vibration of the bus and the consequent shifting of the print upon the page of an observer's newspaper, eye strain would be produced if intensities lower than 7 foot-candles were maintained upon the reading

plane located 36 in. above the floor. Since glare is a cause of eye strain, bare lamps should never be tolerated within the field of vision and this practically excludes them from being used in motorbus lighting. To prevent glare it is necessary to provide some sort of a fixture that will diffuse or modify the light flux given off by the bare lamp. A good lighting fixture will not only diffuse the light but will produce an even field of illumination.

Use of conventional dome-lamps was discouraged by Mr. Roy except in cases where the head-room of the bus is less than 5 ft., as in the case of sedan coaches. Reflector units are more suitable since they produce a very even field of illumination, are easy to keep clean and do not shake to pieces.

By substituting suitable reflector lights for glaring bare lamps or inadequate dome-lamps, the advertising cards are evenly and properly illuminated, thus enabling the bus operator to secure the revenue from this service.

Measurements in an actual motorbus body showed that the percentage of increase in the intensity due to the color of the walls and the ceiling is as shown in Table 1.

TABLE 1—PERCENTAGE OF INCREASE IN THE FOOT-CANDLE INTENSITIES OF MOTORBUS ILLUMINATION DUE TO THE COLOR OF THE WALLS AND THE CEILING

Number of Lighting Units	8	8	8
Type of Unit	Bare Lamps	Dome Units	Reflector Units
Dark Ceiling and Walls	[1]	58	84
White Ceiling and Dark Walls	71	61	110
White Ceiling and Light Walls	..	71	132

[1] Standard upon which increases are based.

From the foregoing it would appear that the best interior conditions would be to provide a white ceiling with light colored walls. Gloss white paint should be used, for it is much easier to clean than the flat color.

The Best Location For Bus Lighting-Fixtures

Lamps placed in two rows with each row from 12 to 15 in. from the side of the bus is by far the most desirable position for them. Here, the reflectors will be out of the way of the standing passengers or those entering or leaving the bus and the light will not be hindered from reaching the reading plane about the seats. To insure an even distribution of light the fixtures should be placed about 3 ft. apart. The last fixture should be placed about 1½ ft. from the rear wall and the others spaced accordingly. In general, the number of ceiling outlets that should be provided in the different lengths of body are listed in Table 2.

TABLE 2—NUMBER OF CEILING OUTLETS FOR DIFFERENT LENGTHS OF MOTORBUS BODY

Length of Body, ft.	16–18	18–20	20–22
Number of Outlets	6	8	10
Size of Lamps, cp.	21	21	21

It is desirable to provide a storage-battery that will supply energy to keep the lamps lighted for 6 or 8 hr. in case of generator failure. This is a safety measure and will prevent the bus from having to be withdrawn from service until its regular time at night.

Bus Lighting-Generators Must Have Large Capacity

The generator chosen should be one that is designed to meet the severe requirements of motorbus service. It should have sufficient output capacity to care amply for the total load imposed upon it and should be capable of running at full rated capacity without any undue rise in its temperature. There are at present four or more companies making generators in capacities of 300 or 600 watts especially adapted for motorbus service. A 1000-watt generator has been developed and can be readily obtained. A well-lighted 25-passenger bus requires 256 or 244 watts for 6 and 12-volt systems respectively. A 300-watt generator will provide enough energy to carry these loads with an excess of 44 and 56 watts respectively.

DO YEARLY MODELS PAY?

T. J. Lítle, Jr., Cites the Disadvantages of This Plan at the Cleveland Section's Meeting

T. J. LÍTLE, JR.

An attack was launched on the yearly-model policy at the Sept. 22 meeting of the Cleveland Section. Taking the side of the opposition, T. L. Lítle, Jr., chief engineer of the Lincoln Division of the Ford Motor Co., presented a most interesting criticism of the almost general practice of announcing new passenger-car models every 12 months. An audience of nearly 200 members heard him stress particularly the retarding influence of this policy on normal, healthy and sound engineering development. The hustle and bustle in engineering and manufacturing departments to put each new yearly model into production leaves little time for careful engineering research and testing. The important points in Mr. Lítle's remarks are abstracted in the following paragraphs.

While the topic assigned for the talk was Cooperation Between the Engineering and the Production Departments, the major part of Mr. Lítle's paper treated the yearly model subject. Troubles in the factory are often traceable to misunderstandings between the engineering and the production departments. The engineer is certainly responsible not only until the time of the completed design, but really until the product is worn out after years of service. With this thought in mind, Mr. Lítle said that he has always been opposed to the yearly-model plan. It is a very big job to lay down a design and put it into production successfully within a few months. The shrewdest engineering guesser cannot help making many mistakes on every new model designed and these are magnified in the hectic rush of the production department to supply the demand created by vivid national advertising sales effort.

Every engineer should spend a part of his time in the field, if Mr. Lítle's recommendations are followed. Thus, he is able to study service troubles first-hand and can secure accurate reports on which to base his engineering development. Occasionally car-owners should be interviewed so that a clear picture can be secured of the performance of cars in the hands of the user.

Yearly-Model Rush Restricts Cooperative Effort

This policy of field visitation and more frequent conferences with production department heads cannot be carried out by an engineer who is busily engaged in grinding out drawings at a rate that would put our forefathers to shame, said Mr. Lítle. Coincident with the rush in the engineering department, the men in the manufacturing division are busy preparing the tools for producing the new model and they have insufficient time for frequent consultations with the designers.

Mr. Lítle called attention to the slowing-up of production of current models which occurs when word leaks out that an announcement of a new model is impending. This results in plant shut-downs; skilled laborers wait gloomily for the advent of new model production. When this does occur, night shifts are required and careful experimental testing of the new product is curtailed. New and untrained men are injected into the factory organization and the older men, who have just passed through a period of enforced idleness, do not work with their accustomed enthusiasm. It takes at least a couple of years to design and perfect a good motor

car, in Mr. Lítle's opinion, and very rarely is it possible to better this time.

Is the Engineer Responsible for Yearly-Model Policy?

Engineers are largely responsible for the persistence of the yearly-model policy, said Mr. Lítle. They are the ones who so often influence the management to adopt radical changes instead of perfecting and refining the existing product. What is the sense, he asks, in changing the bore or stroke of the preceding model by 1/16 in. or of making slight changes in shackle bolts, connecting-rods, bearings and numerous small parts? If the engineer is sufficiently determined, he can modify and improve the existing part and preserve its interchangeability with the preceding model. No good reason exists for changing body hardware once or twice every season with resultant annoyance to the owner who needs service on these parts.

In Mr. Lítle's plea for an enduring design he made it perfectly plain that continual improvement should be made in the product, but the modifications should be made with service on the older cars in mind. Die-cast iron, hardened-forged and pressed-steel pistons are coming, but when they arrive the engineer should not make dimensional changes that destroy interchangeability. If a more efficient hot-spot is fitted, let the public know that it has been borne in mind by having the new device fit the old models. Comparatively few of the old cars will be brought uptodate, to be sure, but the clientele of the company will be convinced that the policy is not one favorable to radical changes and will be convinced that it has made a more conservative investment in transportation.

Discussion of Mr. Lítle's remarks was very active, as might have been expected. It was clear that those present were divided into two distinct camps, one believing in making radical changes as new ideas developed, the other taking the side of perfecting the car by evolution instead of revolution. E. T. Birdsall, one of the founders of the Society, told how in the early days of the industry each new change had to be sold to the public instead of its being accepted as a logical engineering development.

WHEN DOES A TRUCK BECOME OBSOLETE?

Metropolitan Section, After Animated Discussion, Says It Does Not Know

Beginning the new year without a home, or rather its new home being not yet ready for occupancy, the Metropolitan Section, forced to seek other quarters, selected the Hotel Cumberland, New York City, as the locus of its first monthly meeting of the fall season, held on Thursday, Sept. 18. A. F. Masury, chairman of the Section, presided.

F. W. Davis

When Does a Truck Become Obsolete was the question propounded by F. W. Davis, consulting engineer, Waltham, Mass. In endeavoring to find the answer he first reviewed the subject as it had previously been discussed by such authorities as A. M. Wellington and O. B. Goldman, and more recently in articles by F. J. Scarr, R. E. Plimpton, J. F. Winchester, E. E. La Schum and others.

The motor truck, said Mr. Davis, is expensive to purchase, to operate and to maintain. The purchase price depends on the personal choice of the buyer. Then operation begins and following that must come maintenance. This varies from highly efficient supervision to inadequate and ill-advised mechanical attention. He quoted W. E. Parker as saying that a truck should be scrapped when its economic usefulness has been exhausted, but this, he added, requires study to arrive at the meaning of the words "usefulness" and "exhausted."

Motor Trucks Continually Improving

Since the first experimental attempts to transport merchandise by motor vehicle in 1900, the first serious attempts at quantity production in 1910 and the recognition in 1915 of the motor truck as an instrument of dependability and enormous capacity for work, many changes have taken place in the materials used in constructing the motor vehicle, the methods of its production, the interchangeability of its parts and the accessories that improve its ease of operation and efficiency. Its operating economy has been increased by the reduction of first cost and by the lowering of operating expense through better fuel, lubrication and tires, by the interchangeability of parts, by the use of better material and by auxiliaries that are better suited to their purposes. But the development has been entirely in the details. Many trucks purchased in 1910 are still in service.

The automotive industry is too young, according to Mr. Davis, to be able yet to write the life history of a truck, but a parallel may be found in the methods used by the railroads in depreciating their equipment. Locomotives are sent to the shop after a certain time or mileage.

Depreciation reserve, he stated, assures continuity of operation; the most readily adaptable way of determining what it shall be is by the straight-line method. The depreciation rate depends on the first cost, the interest rate compounded, the life of the equipment and the scrap value. Depreciation usually increases with age, for, as the truck becomes older, repair parts are more difficult to obtain. Mr. La Schum has shown that from 1916 to 1921 the cost of maintenance greatly increased but that since 1921 it has decreased. The increase has been attributed to the rise in the cost of labor and materials; the decrease, to correct methods of maintenance.

Some trucks, he said, become "orphans" through the inability to obtain spare parts; others become inadequate for the service to be performed; but a truck still in use and capable of rendering service cannot be said to be obsolete.

Maintenance Problem Complicated

In opening the discussion John McLachlan of the New York Telephone Co. asserted that the maintenance problem was complicated by the fact that after a certain type of truck has been studied for 4 or 5 years a new design usually appears that operates at a much lower cost. The only thing to do is to adopt the new truck. Referring to Mr. Davis' statement regarding the rise in the cost of maintenance with the age of the truck because of the difficulty of obtaining spare parts, he said this confirmed his own experience.

F. K. Glynn, engineer of the same company, then elaborated this statement by submitting figures covering the operation of two groups of 10 trucks each, one consisting of 2-ton trucks, the other of 5-ton trucks, a comparison being made of the cost of operating the trucks over a period of 8 years and over two periods of 4 years each. The figures showed that the cost of maintenance for the second period of 4 years was approximately twice that for the first 4 years, and that the cost of two fleets each operating for 4 years would be more economical than one fleet operating for 8 years. These figures in condensed form are as follows. Considering first the fleet operating for 8 years, the original cost of a chassis, he said, was $2,700; the average operating cost for the period was $12,035; the total was therefore $14,735. At the end of the 8 years the chassis could probably be sold with the body for $300 which would make the net cost for the period $14,435.

In the same way considering two fleets, each operated for 4 years, the original cost of two chassis, $2,700 each, is $5,400; twice the cost of operation during the first 4 years, $4,738, is $9,476; the total operating cost therefore is $14,876.

At the end of the first 4 years the chassis could be sold, without the body, for $450; at the end of the second 4 years the chassis and the body would bring $600, a total of $1,050. This item deducted from the operating cost of $14,876 makes the net cost $13,826, as compared with $14,435 for the 8-year period.

The number of days that the truck is idle while undergoing repairs during the 8-year period is 190; the number of days idle during the first 4-year period is 69, or a total of 138 for two 4-year periods.

Cost of Truck Out of Commission

When a truck goes out of commission 10 or 15 men are idle, so that an additional truck must be hired during this time. The net cost of this spare truck per day after deducting the operating cost is $10. As the difference between the numbers of days idle in the two cases is 52, this would add $520 to the cost of the 8-year chassis. With two chassis two sets of tires would be required, whereas a chassis operating for 8 years would use only one set of tires. Making allowance for this item would add $180 to the cost of the 8-year chassis and bring the total cost for the period to $15,135.

The cost of changing the chassis at the end of the 4-year period is $25. When this amount is added to the $13,826 given above, it will bring the total for the two 4-year periods of operation to $13,851.

Because of the extra days out of service the mileage for the 8-year chassis is 58,145. The mileage for the first 4-year period of operation is 30,125. Multiplying this by 2 gives 60,250, as against 58,145.

During the 58,145 miles the total repair cost was $6,627. During the first 4 years over a mileage of 30,125, the repair cost was $1,956; during the second 4 years, although the tires traveled only 28,020 miles, the repair expense increased to $4,651, or more than twice as much as during the first period.

In the first 4 years the total operating expense for the 8-year trucks was $4,738; in the second 4 years it was $7,297. Of the 190 days that the 8-year trucks were out of commission for repairs, 69 occurred during the first 4 years and 121 during the second 4 years.

Operation of 5-Ton Trucks

The 5-ton trucks show figures that are very similar. These trucks operating for the 8-year period covered 58,897 miles; the total repair cost was $9,692. During the first 4 years they covered 30,532 miles at a repair cost of $2,999; in the second 4 years the mileage was 28,364 and the repair expense $6,693, or more than double.

The total operating cost for the first 4 years of the 8-year period was $7,620; for the second 4 years it was $11,916, a total for the 8-year period of $19,526.

The days lost in repairs over the 8-year period were 224, only 78 of which occurred during the first 4 years. In the second half the number was 146, or nearly double. The remaining figures for the 5-ton trucks bear out those already given.

F. J. Scarr said that he was in accord with everything Mr. Davis had said except two points. He believed that a definite policy of depreciation for all kinds of business is not only impracticable but uneconomical. Each fleet must be placed upon its own operating conditions and governed accordingly. The depreciation period, he said, should equal the economic life of the fleet as nearly as possible.

Arithmetical Determination of Depreciation

The second point is with regard to the formula given in Mr. Scarr's paper. This formula, he said, was simply an effort to resolve depreciation into an arithmetical problem that would decide the question whether a vehicle should be continued in service or retired. The most expensive period in the life of a vehicle is that just before overhauling. Then is the time to determine from the past record of a fleet of trucks whether the operating expense of the next period will equal the cost of a new vehicle. The economical operation of a fleet, he said, depends on four points: (*a*) selection of the proper vehicle, (*b*) proper inspection, (*c*) efficient and economical overhauling at the proper time and (*d*) retiring the vehicle at the end of its economical life.

In reply Mr. Davis asserted that at the end of the year it is necessary to wind up the books. If the books cannot be wound up until the end of the life of the vehicle what could one do? Would one plead with the Government that the depreciation had been overstated or understated? The question is, whether depreciation is a book item or a matter of mechanical wear.

Results of Deferred Maintenance

In his experience with small motorbus companies, declared R. E. Plimpton, he had found that if he called on them early in the morning he usually found that the owners and executives had been up the night before making repairs; a case of deferred maintenance or postponed overhauling. He believed that elaborate overhauls though more expensive at the time are less expensive in the end.

M. C. Horine wished to emphasize the importance of keeping truck users informed regarding changes and improvements made in the product for the purpose of benefiting the maintenance, and of making new parts interchangeable with old ones. He believed that the flat-rate system of charging for repairs would enable users to foresee their maintenance costs in a way that they had not been able to do heretofore.

E. E. La Schum agreed with Mr. Davis in that it is not possible to find a fixed method of depreciation applicable to all trucks; he did not agree with Mr. Horine that it would be better to replace the telephone company's trucks after the 8-year period; he did not believe that Mr. Glynn's figures proved anything, because he said he knew that depreciation must be figured on a periodic basis, and that if Mr. Glynn had used the cost of the original truck plus interest, depreciation and insurance and had added them to the 4-year life, assuming that he might have depreciated the truck on a 5-year basis, he might have found that the second 4-year period was more economical, that is, that the cost of repairs in the second 4 years was less than the depreciation, interest and insurance plus the repairs on the new equipment.

DETONATION CONTROLLED CHEMICALLY

Midgley Tells Washington Section of Anti-Knock Fuel Research

Thomas Midgley, Jr.

In the course of a vast number of experiments conducted by Thomas Midgley, Jr., in his search for the best anti-knock material for use in gasoline-engine fuels the elements fluorine, iodine, lead, nitrogen, selenium and tellurium were each found to be more or less effective in relieving detonation. For one reason or another, however, most of the elements proved to be objectionable; some were too expensive, others were corrosive and the use of others resulted in obnoxious exhaust odors. Accordingly all were eliminated from the investigation with the exception of lead which in the compound tetra-ethyl lead fulfilled the requirements of a practical anti-knock material without possessing the important disadvantages characteristic of other compounds that were tried. As a result of the research, described very graphically by Mr. Midgley before the Sept. 26 meeting of the Washington Section, gasoline treated with tetra-ethyl lead has been produced and is being marketed

extensively throughout the Counry in the amount of 500,000 gal. per day. Outstanding among the advantages claimed for this anti-detonating fuel is its adaptability to use in high-compression engines which by virtue of this feature operate more efficiently than the low-compression type.

Introducing his account of the experimental work that led to the choice of this lead compound Mr. Midgley presented a brief analysis of the causes of detonation and the requirements that must be met by a suitable anti-knock material. He showed by equations and graphs how the velocity of flame-travel is a function of the pressure difference between the front and rear of the flame-front and how the excessive pressures that result in knocking can be controlled by the use of a catalyst, which regulates the rate of flame-travel.

A most interesting feature of the experimental work was the procedure of selecting, at first at random, of different compounds and successively studying their effect upon detonation until finally the most satisfactory material was found. This process of selection and test included some 2000 samples.

At the conclusion of his address Mr. Midgley answered a number of questions from the floor. It was brought out that so far as anti-detonating qualities are concerned, no real choice can be made between ethylized gasoline and the benzol blends. The outstanding drawback to the use of the benzol blends was said to be the inadequate supply, the maximum quantity available under ideal conditions being estimated as 20 per cent of the gasoline that is now marketed in the United States.

PRODUCTION MEETING THIS MONTH

Comprehensive Program of Valuable Papers and Factory Visits Arranged

On Oct. 22 to 24, in the General Motors Building, Detroit, the third National meeting of the Society devoted to manufacturing problems of the automotive industry will draw together production men from all sections of the Country. So comprehensive is the program, that the meeting has been increased from 2 to 3 days' duration. Nearly 20 valuable papers on factory methods will be presented. The program printed below is the best argument in favor of attendance.

There are few production executives in the automotive industry who are not seeking ways and means to reduce manufacturing costs at this time. The Production Meeting papers will contain many cost-reduction suggestions. The program is sufficiently comprehensive to touch nearly all phases of production engineering. Points that are not covered in the papers themselves can be brought out in the question and discussion period following each of the papers. A greater time will be available for open discussion of the papers than has been the case in previous Production Meetings.

Ample opportunity will be afforded for production men to meet informally with one another at this year's Production Meeting. A longer luncheon period will be allowed for just this purpose. Then there is the Production Dinner. You may be sure that the speeches will be worthwhile. Watch for the Dinner program in the next *Meetings Bulletin.*

Arrangement of Sessions at Production Meeting

	Wednesday, Oct. 22	Thursday, Oct. 23	Friday, Oct. 24
Morning	Registration Reducing Manufacturing Costs A. L. DeLeeuw, Consulting Engineer, New York City Coining-Press Operations on Automobile Parts A. R. Kelso, Hudson Motor Car Co.	Utilization and Prevention of Waste Carl B. Auel, Westinghouse Electric & Mfg. Co. Salvage of Tools L. A. Churgay, Maxwell Motor Corporation Reducing Wood Waste in Body Manufacture B. Naaglevoort, Towson Body Co. Combating the Checking of Wood in Drying Ovens H. D. Tiemann, Forest Products Laboratory	Supervision of Factory Maintenance; Reducing Its Cost Papers by: E. E. Remington, Ford Motor Co. L. A. Blackburn, Olds Motor Works Fred Sharp, Oakland Motor Car Co.
Afternoon	Experience with the Group-Bonus Plan H. G. Perkins, Maxwell Motor Corporation Reducing Labor Turnover C. A. Lippincott, Studebaker Corporation of America Methods of Shipping Motor Cars Ben Moore, Dodge Bros. and Frank Henry, Studebaker Corporation of America	Some Notes on Tool Design Joseph Lannen, Paige-Detroit Motor Car Co. Avoiding Mistakes in Tool Design Paul V. Miller, Taft-Peirce Mfg. Co. Improvements in Nickel-Plating W. H. Graves, Packard Motor Car Co. Durability of Plated Surfaces W. M. Phillips, General Motors Corporation	Factory Visitation. Optional Visits to Ford Motor Co.—Highland Park plant, Continental Motors Corporation, Hudson Motor Car Co. and possibly others.
Evening	Automobile Glass Manufacture, Inspection, Defects and Salvage John H. Fox, Pittsburgh Plate Glass Co.		

The Meetings Bulletin describing the final program will be mailed to the entire membership about Oct. 10. It will include an application blank for Hotel rooms and tickets for

THE PRODUCTION DINNER AT THE HOTEL STATLER.

RESERVE YOUR SEAT EARLY

Some Notes on Automobile Stages in California

By F. D. Howell[1]

Automotive Transportation Meeting Paper *Illustrated with* Photographs

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

TRANSPORTATION by motorbus, although of recent origin, has advanced rapidly in its development, but is still undergoing a process of evolution. Less than 10 years ago, motor carriers were mostly "jitneys" and were heartily disliked by electric-railway officials. Now, motorbuses are developing a field of their own and are rendering a service not supplied by any other transportation agency, two of their most valuable functions being the building up of new territory and acting as feeders to established lines in the more thickly settled areas. The first steps in their development took place while engaged in local service but the trend toward interurban business soon became manifest.

In California, within the last 10 years, the interurban business has increased from that of a few isolated individuals to the operating of approximately 1000 vehicles, which cover the entire State and in 1923, carried about 25,000,000 passengers. The service rendered by automobile stages is divided into three distinct classes: (*a*) local city-service, (*b*) local intercity-service and (*c*) through-intercity service. Many manufacturers have endeavored to build what they call "stage chassis," having in mind their possible adaptability to freight service. But the requirements of passenger service differ greatly from those of freight service and a special type of chassis is necessary. These requirements are described in detail.

Many parts of the equipment should be improved. The braking systems at present in use are said to be entirely inadequate. Data are given concerning the wear of both the emergency-brake and the foot-brake linings. Wooden wheels have been unsuccessful, but when cast wheels are used the wheels should be cast without the hub and the hubs fitted to them. Troubles due to the use of dual rear-wheels are being overcome.

In the opinion of the author, sufficient study has not been given to the tire problem. The products of different tire manufacturers do not match. Different makes of tire should be made interchangeable and the same size of tire should be used for the whole fleet. To get the longest life from a tube, the suggestion is made that a size should be selected that will just fill the casing before sufficient air is put into the tube to stretch the rubber. In such a tube the tread will not stretch "paper thin" and will not be easily punctured.

In the stage and motorbus business the heaviest expenses are those due to (*a*) obsolescence of bodies, to keep abreast of the times; (*b*) the reconstruction of stock chassis, to make them conform to stage needs and (*c*) maintenance. Reconstruction of bodies is necessary because new cars must be modified to meet local conditions. One modification usually involves another. On rebuilt cars the annual maintenance cost amounts to more than 60 per cent of the cost of the new equipment.

The statement is made that if manufacturers do not pay more special attention to stage equipment and prepare themselves to fill buyers' specifications, general assembling plants will spring up, or stage companies will be forced to expand their present plants to complete the assembling.

TO those who know how speedily the new mode of transportation by motorbus has come into national importance within a few years it is unnecessary to make any introduction to the subject of the development of the modern motor carrier. For the purpose of making the record complete, however, I should like to

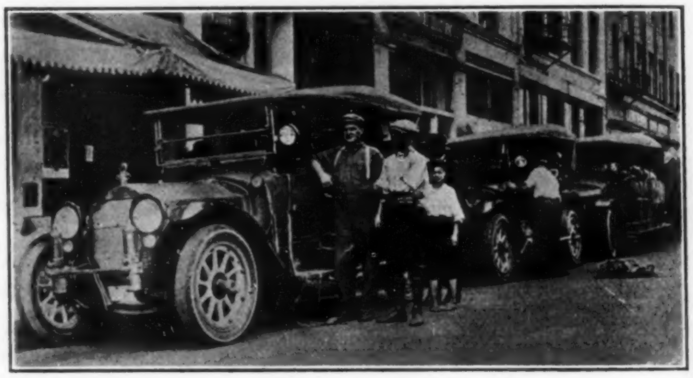


Fig. 1—The Los Angeles Terminal of a Stage Line in 1918
This View Shows Two Intercity Through-Stages and a Local Vehicle Ready To Load. The Ticket Office Is Located in the Store Opposite the First Car. All Passengers Were Received and Discharged at the Curb Line

begin this paper with the statement that the modern motor-stage, comfortable as it is, nevertheless is still in process of evolution. A study of the recent events and the typical changes in that process of development, now more steady and better directed than at first, may serve to indicate wherein further improvements are needed and whither the present trend is heading.

Less than 10 years ago, the motor carriers were chiefly "jitneys," operating as outlaws, condemned as pirates and parasites and right heartily cursed and hated by electric-railway officials. Today, with interurban systems in the mountains and valleys and across the deserts, the motor carriers are rendering a service not supplied by any other transportation agency and are doing work in building up new territory without which many isolated Western towns would be years behind their present development. In the more thickly-settled areas, electric-railway operators have recently learned that the motor carrier can be a most valuable ally, and the two forms of transportation are beginning to work together in harmony to their mutual advantage.

[1] M.S.A.E.—Vice-President and assistant general manager, Motor Transit Co., Los Angeles.

Evolution of the Motor-Carrier Industry

Although the first developments of the motor vehicle as a common-carrier were in local service, the trend was rapidly toward interurban business, of which it now receives a major share and for which a very special class of equipment has been developed. Since the early days of the industry, little attention has been given to purely local service, except in isolated cases, such as in the City of Long Beach, where the B. & H. Transportation Co. has developed an extensive local system; in Everett, Wash., where the Northwest Traction Co. operates; and in Pasadena and Los Angeles, where the Pacific Electric Railway and the Los Angeles Railway within the last year or so have begun the use of single and double-deck motorbuses as substitutes for non-paying electric-lines and as feeders within the corporate limits of the city.

Interurban motor-stage service, however, has grown up within the last 10 years. Beginning with the irregular operation of a great number of individuals using all makes of five and seven-passenger cars, a healthy industry has developed that renders a regular and regulated transportation service, covering the entire State of California. In some parts, the motor carriers operate in competition with steam and electric lines; elsewhere they serve as feeders; but large areas of California are served by motor carriers exclusively. Approximately 250 stage companies were in the common-carrier passenger-service during the year 1923, operating over 1000 vehicles and carrying approximately 25,000,000 passengers.

Fig. 1 shows the Los Angeles terminal of a stage-line in 1918, two intercity through stages and one local stage being ready to load; the ticket office is in the store opposite the leading car. All cars were then loaded and unloaded at the curb line.

Fig. 2 shows a 1924 stage-depot waiting-room. This depot is diagonally across the street-intersection from that shown in Fig. 1.

Fig. 3 shows four intercity through-stages in slips, loading. This is the loading-platform of the waiting-room shown in Fig. 2.

Practically all the motor-lines in California began operation with the heavier passenger-cars, purchased second-hand; as the business grew, the chassis were lengthened and special bodies were built to increase the seating capacity. As these pioneers developed financially, the rebuilt cars were replaced with special equipment built to order on truck chassis. Although many of the lines of the early pioneers are still using rebuilt cars, it is only a question of a short time before this equipment will become extinct. Not only is the maintenance cost excessive on such cars, but only cars of the older models can be used for this purpose, and the supply is therefore limited. Equipment of this sort is mentioned only to show the transition, rather than the type, and will not be discussed further.

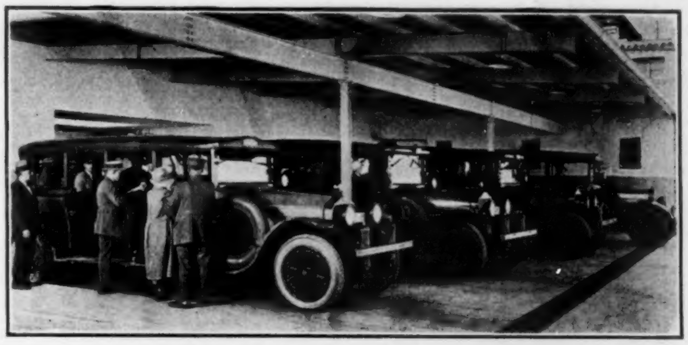


Fig. 3—Intercity Stages Receiving Passengers at the Los Angeles Union Stage Depot
Each of These Four Stages Accommodates 18 Passengers. Note the Contrast between the Vehicles and the Facilities Afforded in This Illustration and in Fig. 1

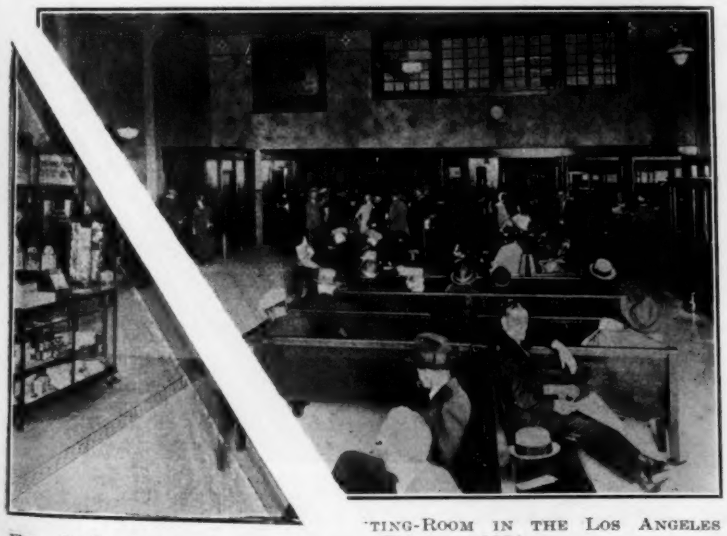


Fig. 2—Interior of the Wa ting-Room in the Los Angeles Union Stag Depot in 1924
This Depot Is Diagonally Acros the Street from the Terminal Shown in Fig. 1

The companies that have foreseen the early demise of the converted automobile but have not had the money to build rolling-stock suited to their needs have been obliged to take the product of the truck manufacturer as it came from the factory and have a body fitted to it. Others, endeavoring to meet their needs in their own shops, are assembling stock units or altering the frames of chassis and building bodies on them.

Passenger Stages a Hybrid Product

The requirements of stage service lie between the products of the passenger-car manufacturer and those of the freight-car manufacturer but, of the two, a freight car can be made over to meet the needs of stage service, whereas a passenger car cannot. Freight-car manufacturers, generally speaking, all have their eyes on the stage business and are endeavoring to create something that they can call a "stage chassis"; but, at the same time, being mindful of the fact that the bulk of their product will be absorbed for freight service, they have been careful to produce a car that could be advertised as a stage chassis but could readily be sold as a freight unit.

The requirements of passenger service differ materially and in many particulars from those of freight service. For instance, a passenger car must have speed and be able to maintain that speed for long distances. It must have adequate pick-up and a quiet engine. It must have springs that will yield the maximum of riding-comfort under all loads. It must have rigidity of frame in the plane of the floor, to avoid warping, twisting and distorting of the body. It must have a low center of gravity when loaded, for safety against overturning and for convenience in loading and unloading passengers. It must be mounted on pneumatic tires and be able to operate 18 hr. a day. These requirements, you will see, are practically all contrary to those essential to freight hauling.

Investigation of the service of freight and passenger carriers in California indicates that the passenger cars in common-carrier service operate about twice as many car-miles per day as are covered by common-carrier freight cars, and from three to four times as many as

the cars of the ordinary contract-freight hauler; in other words, the mileage of individual cars in common-carrier passenger-service is about 60,000 or 80,000 miles a year.

Three Types of Stage Service

Three types of service are furnished in California, each requiring different treatment, as follows:

(1) Local city-service, which is analogous to street-car service

(2) Intercity local service, a service between the local city-service and that offered by interurban electric-railways

(3) Intercity through-service, which is analogous to that furnished by interurban electric-railways and steam railroads

Recent examples of passenger equipment are shown in the accompanying illustrations. Fig. 4 shows a 22-passenger through-intercity side-door car, built on a White Model-50A chassis, for the Spokane, Portland & Seattle Transportation Co. of Portland, Ore.

Fig. 5 is an 18-passenger through-intercity side-door car built by the Motor Transit Co., and has a White-GN engine, 220-in. wheelbase and dual tires in the rear.

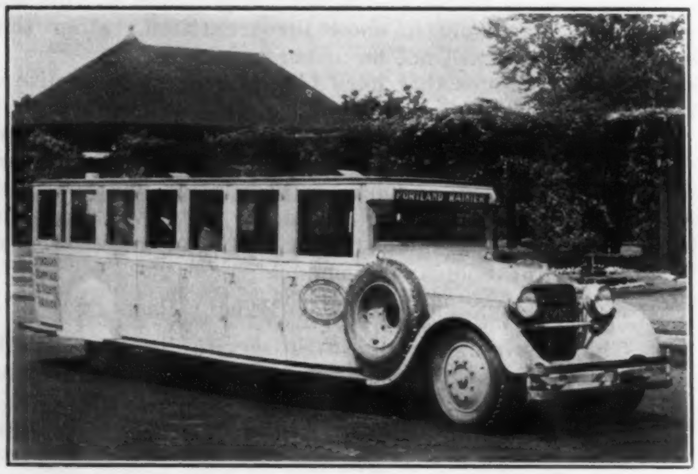


Fig. 4—A 22-Passenger Bus for Through Service
This Vehicle, Which Is Intended for Express Service, Is Equipped with Side Doors and Has a Wheelbase of 198 In.

Fig. 6 shows the interior of the 18-passenger car shown in Fig. 5. Notice the inclined floor under the seat in front, making a footrest for the passenger behind. This knee-room looks cramped but, with the opening under the rear of the front seat for the feet, is in fact very liberal.

Fig. 7 is an intercity local street-car-type body built by the Motor Transit Co., with White Model-50A engine, and dual tires in the rear. Fig. 8 is a view of the interior of the intercity local street-car-type body shown in Fig. 7.

Fig. 9 shows a 24-passenger parlor-car-type Fageol safety-coach. Fig. 10 is a 29-passenger street-car-type Fageol safety-coach, having full head-room.

Fig. 11 illustrates a 26-passenger side-door six-wheel intercity car built by the California Transit Co. Note the cast-aluminum wheel with removable hub.

Fig. 12 shows the Mack street-car type. Fig. 13 is a Mack car of the de-luxe type.

Most Used Models

Of the types of car used for local service, both city and intercity, the 25 to 30-passenger street-car-type vehicle prevails. The White, Fageol, Mack, Reo and a few others can be used as built by the factories, but for the bodies used on intercity through-service the frame and attachments must be altered. In California, among the higher-priced cars used for stage service, the White has been the most popular but, since the advent of the Fageol safety-coach, this product has been running the White a very close race for popularity. Of the cheaper cars, the Reo has by long odds been the favorite. A new departure in a six-wheel vehicle that is now being put on the market by the California Transit Co. of Oakland is being watched with considerable interest. Several cars of this type tested by the builders in regular service for 100,000 miles have all been reported satisfactory in every way.

Fig. 5—Another Type of Through-Service Bus
Like the Bus Shown in Fig. 4, This Bus Is Equipped with Side Doors. The Wheelbase Is Longer, However, Being 220 In., and Dual Tires Are Used on the Rear Wheels

Requirements for Stage and Motorbus Service

The requirements for the use of these classes of service are about as follows. A car, well-suited to local city-service similar to that offered by street-cars, should have the maximum seating-capacity, say 28 to 30 passengers, with full head-room for standing passengers, the floor level as close to the ground as possible for ease in loading and unloading, the entrance and the exit on the forward right-hand side of the car, abreast of the operator or driver, with an aisle extending longitudinally along the center-line of the car. The operator should have control of the loading and the unloading of passengers and the collecting of fares without leaving his seat; for the collecting of fares under 25 cents, the car should

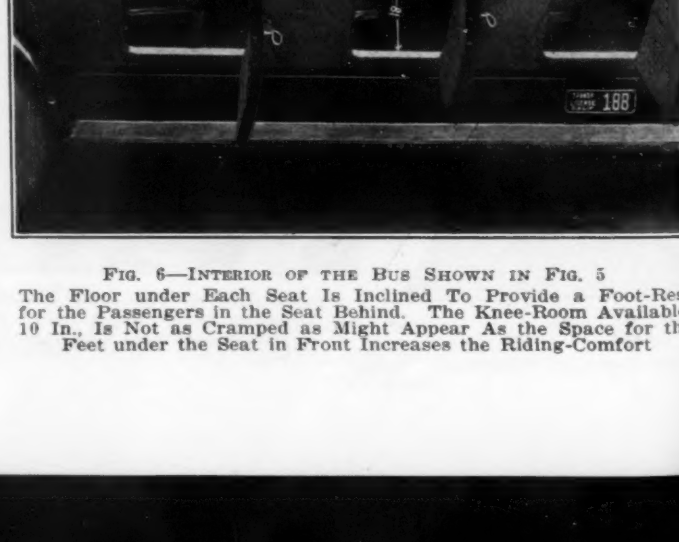


Fig. 6—Interior of the Bus Shown in Fig. 5
The Floor under Each Seat Is Inclined To Provide a Foot-Rest for the Passengers in the Seat Behind. The Knee-Room Available, 10 In., Is Not as Cramped as Might Appear As the Space for the Feet under the Seat in Front Increases the Riding-Comfort

be equipped with recording fare-boxes, with a release of the money collected to the operator after it has passed through the register. Pneumatic tires should be used, both front and rear, with dual tires in the rear; and all tires should be interchangeable.

In this service the average speed between terminals is 10 m.p.h., the maximum being from 15 to 20 m.p.h., and the usual condition being such as to require preparations to stop at about the time the maximum speed is reached. As to engine performance and the transmission, quick smooth get-away and acceleration, the minimum vibration and smooth action through gear-changes

Fig. 7—A Street-Car Type of Bus
This Vehicle Is Used in Intercity Local Service, Which Occupies a Place in the Transportation Scheme between the Local City Trolley-Car and the Interurban Electric Railway. This Bus Is Equipped with Dual Tires on the Rear Wheels

are required. As there is little chance to use an over-drive, it had better be left out.

For low grades and paved streets, the engine power required is approximately 1 hp. per passenger-seat, N. A. C. C. rating, and a four-cylinder engine is to be preferred on account of the maintenance expense. In city streets, high road-clearance is not necessary but

Fig. 8—Interior of the Intercity Bus Shown in Fig. 7
Comfortable Seats Upholstered in Leather Are Provided with Broad Arm-Rests and Hand-Holds for the Standees. Note the Fare-Box at the Left of Entrance Door That Folds Back against the Front of the Bus

short turning-radius and 30-ft. length over-all are necessary for handling satisfactorily around street-corners. The wheel-gage is immaterial. Some of the more popular models used in this service in California at present are listed in Table 1.

Local intercity-service is in many respects the same as

Fig. 9—A Center-Aisle Parlor-Car Type of Bus
This Vehicle Has Seats for 24 Passengers. A Less Pretentious Vehicle of the Same General Type Is Shown in Fig. 10

local-city service, except that, instead of making frequent stops at successive street-corners, the stops are farther apart, ranging from several hundred feet to several miles. Under these conditions the average speed between terminals is 25 instead of 10 m.p.h., and the maximum speed, 35 m.p.h., the legal limit in California. Other conditions are the same, except that an over-drive can here be used to advantage on the longer runs between stops; road-clearance must be considered, as must wheel-gage, because the reconstruction or repairing of highways often causes detours of traffic temporarily over

TABLE 1—DETAILS OF MOTORBUSES USED IN LOCAL CITY-SERVICE

Make of Bus	Mack	Fageol	White
Seating Capacity	29	29	25
Make of Engine		Hall-Scott	Type *GR*
Number of Cylinders	4	4	4
N. A. C. C. Rating, hp.	28.9	28.9	28.9
Wheelbase, in.	230.5	218.0	198.0
Distance from Ground to Floor, in.	..	22	..
At Front Axle, in.	26		30
At Rear Axle, in.	32		36

unimproved roads that soon become cut-up and rutted and in wet weather would mire the very low under-slung models.

Through-intercity service is used extensively by local as well as tourist trade and differs from the local type in that stops are infrequent, usually only at depots, and the operators can step out of the cars to open the doors,

Fig. 10—A Street-Car Type of Bus
The General Design of This Vehicle Is the Same as That of the Bus Shown in Fig. 9. This Vehicle Will Accommodate Five More Passengers. The Full Head-Room Available Is a Feature Worthy of Special Mention. The Powerplant Is a Six-Cylinder Engine

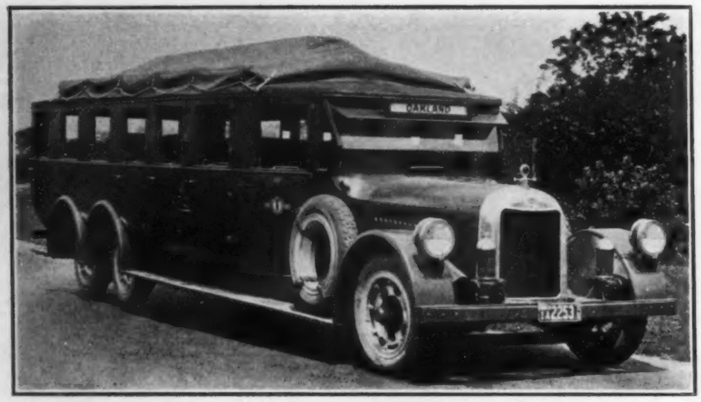


FIG. 11—A SIX-WHEEL INTERCITY BUS
Cast Aluminum Wheels with a Removable Hub Are a Feature of the Equipment. This Vehicle, Which Is Provided with Side Doors, Will Seat 26 Passengers

load and unload passengers and collect fares. These runs have rest and meal stops in transit. The front-entrance center-aisle body is not necessary, nor is head-room required, as in a local motorbus. Side-door construction allows the minimum head-room, some models now in use having as little as 4 ft. 6 in. in the clear. The car most frequently used in this service is the side-door touring-type, with long racing lines, four passengers to a seat and two with the operator, the total seating-capacity being from 18 to 26 passengers. This service requires a more comfortable seat than does that of the local car; and on account of the long rides, more leg-room, foot-rests, deep cushions and soft backs are needed.

When the street-car type of motorbus is used in this service, it requires greater head-room than does the side-door type. It is generally equipped with chairs, or heavily upholstered seats; this arrangement, made to afford more comfort for the passengers, reduces the capacity about 20 per cent. The average speed between the terminals in this service is 30 m.p.h., the maximum being 35 m.p.h. The transmission and engine requirements are the same as for other service, the over-drive being useful on low grades and paved roads. The horsepower required on occasional short grades not exceeding 4 or 5 per cent is 1 hp. per passenger-seat, with a ratio of dead load to live load of 2 to 1; on long grades up to 7 and 8 per cent and having much curvature with long distances, causing the speed to be reduced to 15 or 18 m.p.h., the power required is approximately 1.5 to 2.0 hp. per passenger-seat. The horsepower on grades depends, of course, on the grades and on the speed to be

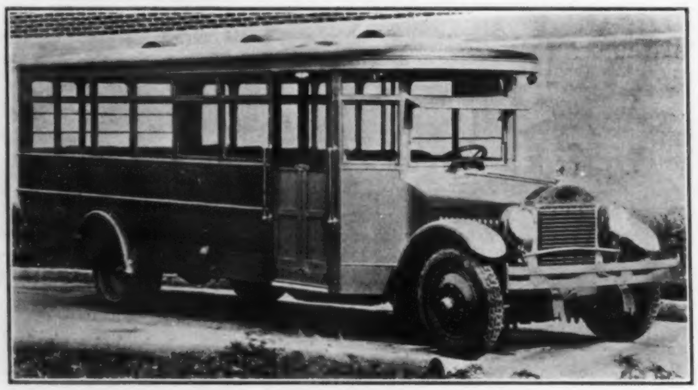


FIG. 12—ANOTHER STREET-CAR TYPE OF BUS
The Body, Which Will Accommodate 25 Passengers, Is Mounted on a 196-In. Wheelbase Chassis. The New Type of Bumper Is Permanently Fixed in Position and the Head-Lamps Have Been Brought Forward

maintained and must be great enough to carry the car at the maximum safe speed at all times. In intercity through-service the six-cylinder engine is to be preferred on account of its greater flexibility.

MECHANICAL FEATURES

Gear-ratios for any service, of course, depend on the nature of the roads and the grades. The public demands a reasonable speed at all times, considering the character of the road being traveled; and, no matter how steep the grades may be or how slowly a car must travel to climb them, when the car is off the grade, the public demands immediate pick-up and a continuation of the journey at normal speed. Many runs involving from 50 to 100 miles of low grades, then a climb into the mountains on 10 to 27-per cent grades on dirt roads, must have double-reduction gears or a compound transmission, if they are to meet the requirements; otherwise the part of the line having the low grade would have to be handled by the standard equipment, and the passengers would have to change cars at the foot of the mountain. Even though the standard equipment might make the grades, it would be too slow for comfort going up and would be unsafe to use because of the danger on the down-hill trip, when entire dependence would have to be placed on the brakes.

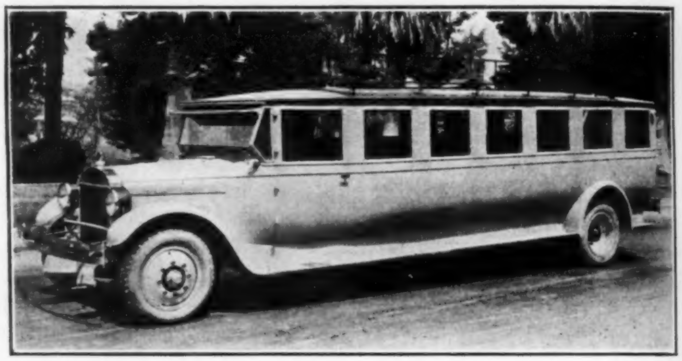


FIG. 13—A DE LUXE TYPE OF BUS
This Vehicle Is a Product of the Same Company as the Plainer Type Illustrated in Fig. 12

Fig. 14 shows a mounting for such an auxiliary transmission. With this combination the vehicle is good for any grade at a safe speed, up or down, without reliance on brakes, except for stops, yet will run smoothly and easily at the maximum speed on paved roads with low grades. This assembly admits of speeds of from 3.27 to 45.00 m.p.h. at an engine speed of 1200 r.p.m.

BRAKES

A technical discussion of brakes would be out of place in this paper, but the subject should at least be touched on. The brake equipment generally supplied, that is, that with brake-bands expanding and contracting on a brake-drum on each of the rear wheels, and that on the drive-shaft, are not entirely adequate for the equipment turned out for freight units, and are less adequate when applied to passenger units, on account of the higher and more sustained speeds. The adjustments are complicated and not such as an average driver can make satisfactorily on the road; and the relining expense is very heavy. It may be that, with all the experimenting now going on, brakes will shortly have a brake-assembly that will meet the needs of the stage.

It may be of interest, however, to give some statistics on the wear of brake-linings. On one route, having 80 miles of low grades and few curves, 40 miles of 6 and 7-per cent grades, tortuous alignment and sharp curves,

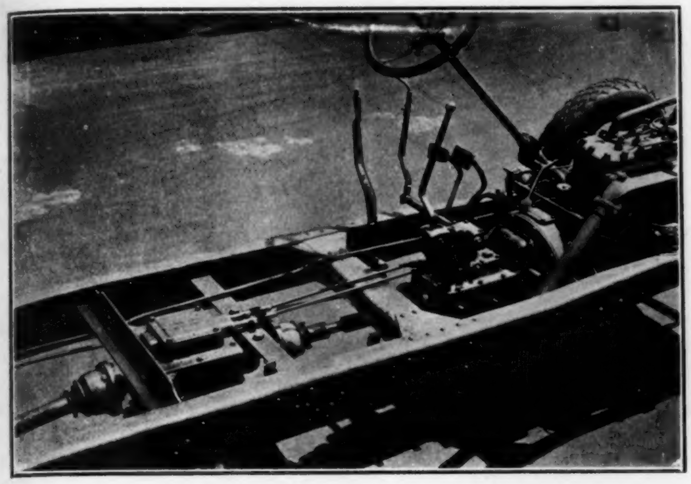


FIG. 14—MOUNTING FOR THE AUXILIARY TRANSMISSION USED IN CLIMBING OR DESCENDING MOUNTAINS
This Combination Enables the Vehicle To Make Any Grade, Either Up or Down, at a Safe Speed without Relying on the Brakes Except for Stops and Yet It Will Run Smoothly and Easily at the Maximum Speed on Low-Grade Paved Roads. A Speed Range of from 3.27 to 45.00 M.P.H. at an Engine Speed of 1200 R.P.M. Is Provided by This Transmission

all paved, 10 cars running a total of 470,049 miles required 81 emergency-brake relinings and 164 foot-brake relinings, or one emergency-brake relining for approximately every 5850 car-miles run and one foot-brake relining for approximately every 2930 car-miles. These were 11-passenger cars, mounted on 2-ton chassis, weighing, loaded, 8200 lb. each. Ten cars, running a total of 497,215 miles, on a 134-mile route having low grades, paved roads, one hill with 7-per cent grade, ½ mile up and the same distance down, required 43 emergency-brake relinings, and 109 foot-brake relinings, or one emergency-brake relining for every 11,550 miles and one foot-brake relining for every 4970 miles. These were 18-passenger cars, on 2-ton chassis, weighing, loaded, 11,350 lb. each.

An 18-in.-diameter brake-drum with 3.5-in. face gives a weight of car loaded of approximately 20 lb. per sq. in. of brake surface for the 11-passenger car, and 28.25 lb. per sq. in. for the 18-passenger car, whereas the brake-lining manufacturers recommend 12.5 lb. per sq. in. as about the proper relation.

SINGLE AND DUAL WHEELS

Wooden wheels in California are not successful, for they dry-out quickly and cost a great deal to keep in order. Cast-steel wheels with the hubs cast in are very expensive to maintain. If the hub is damaged, it costs $15 to $17 apiece to fill in and reface the bearing races. Wheels should be cast without the hub so that any hub can be fitted to them. Fig. 15 shows a crankcase-aluminum wheel of this kind that has been in use for a year or more.

All rear wheels, especially dual wheels, should be fitted with two bearings and be designed so that the tire will run true, and the air-valves will be accessible. We have had considerable trouble with dual wheels and single bearings in the past, but some of the later models now provide for two bearings and show very good results.

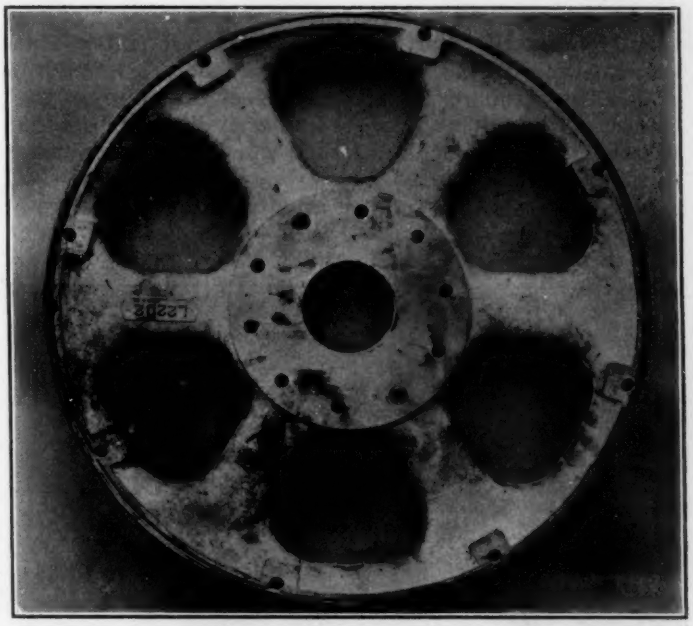


FIG. 15—A CAST-ALUMINUM WHEEL OF THE TYPE THAT HAS BEEN IN USE FOR OVER 1 YR.
These Wheels Are Made without Hubs So That Any Desired Type Can Be Fitted to Them. The Material Used in Casting These Wheels Is the Same as That Employed for Aluminum Crankcases

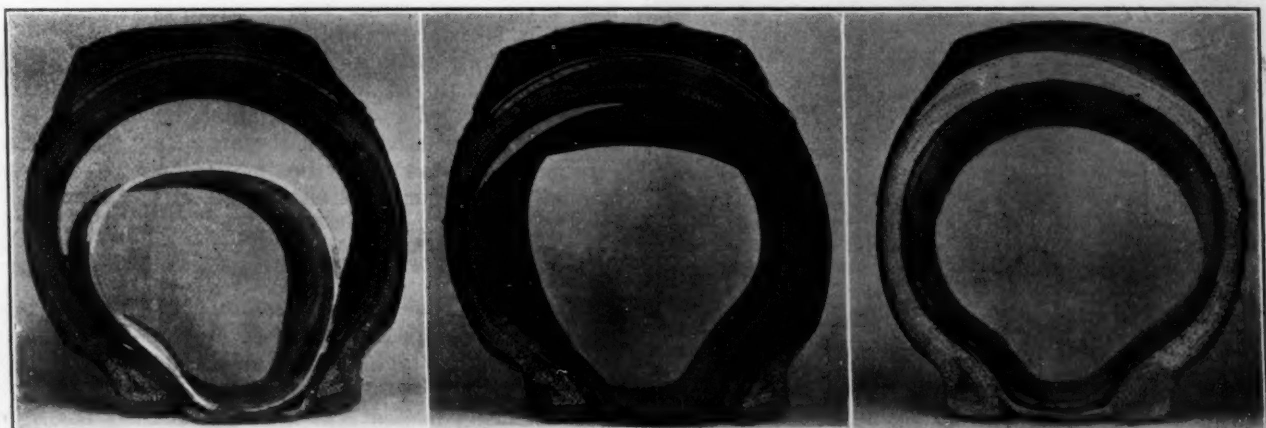


FIG. 16—THREE TYPES OF INNER TUBE THAT CAN BE USED WITH A 34 X 5-IN. CASE
The Regular 34 x 5-In. Tube at the Left Was Not Found Satisfactory Since when Filled with Air but Not under Sufficient Pressure To Distend It, It Filled Only Approximately 50 Per Cent of the Casing's Cross-Sectional Area. The 35 x 6-In. Tube in the Central View Fits a 34 x 5-In. Casing without Buckling at the Rim and Has Given Much More Satisfactory Results than the Standard 34 x 5-In. Tube. The Tube at the Right Is a 34 x 5-In. Special Oversize Ring Shape Designed To Fit the Casting without the Aid of Air-Pressure and Having the Inner Perimeter Molded To Fit Flat against the Rim. This Last Tube, However, Is Not Commercially Available at Present

Urgent Need of Standardized Casings and Tubes

The pneumatic tire of today is one of the wonders of the world, a triumph of engineering; to it, more than to any other one thing, is due the success of the automobile. Sufficient study, however, has not been given to tire equipment for motorbuses and stages, particularly in the matter of standardizing the product of different manufacturers. Tires are classified according to their outer and cross-sectional diameters, yet many of the products of different manufacturers will not match, one with the other; and the common-carriers cannot be expected to carry a miscellaneous assortment of stock of different brands, if it be required to assign different brands to different cars. To satisfy the imperative needs of the stage business, all stock purchased of a given rated-size should be interchangeable, so that one car can assist another on the road in case of tire trouble. A single size of tire for the whole fleet, regardless of the weights of the different cars, is also desirable; and dual tires on the rear wheels have been of material assistance toward accomplishing this end. Although a single tire-standard for an entire fleet might mean that some cars would be over-tired, the slight waste in that respect would be much more than offset by the advantage of interchangeability.

Tubes also require further attention, fully as urgently as do casings, When a tube, filled with air but not under enough pressure to distend it, is put into a casing of standard size, it will fill approximately only 50 per cent of the cross-sectional area of the casing. After being inflated and enlarged to fill the casing completely, it is like a toy balloon; touch it with a pin-point and you will have a hole many times the size of the pin. After a few miles of service, the portion near the tread becomes so stretched that it will take a permanent set and remain "paper-thin" even after being deflated and removed from the casing. Obviously, such a tube is not fit to go back into service. Experience has shown that a tube that will just fill the casing before enough air is put into it to stretch the rubber will give the longest life under stage use and can be replaced from time to time after having been removed from the casing. In such a tube, the tread portion does not stretch "paper-thin," as in the case of those of standard size, and, since it is not distended like a toy balloon, it will not be easily punctured. When it is punctured, say, by the sharp point of a tack, the hole does not extend many times the size of the tack; on the contrary, the rubber will tighten around the tack and prevent even a slow leak. I have seen a nail extending ¼ in. inside the casing that did not puncture a tube of this character. The inner diameter of some standard tubes of the 36 x 6-in. size is so short that they will fit neatly into some 34 x 5-in. casings without buckling at the rim. This tube nearly fills the 34 x 5-in. casing and has given very much more satisfactory results than 34 x 5-in. standard tubes. Some manufacturers are now experimenting with a tube designed to fit the casing without the aid of air-pressure and having the inner perimeter molded to fit flat against the rim. This, I believe, is a great advance in the art of tube manufacture, especially for the stage business; it is to be hoped a commercial product will shortly be on the market. (See Fig. 16.)

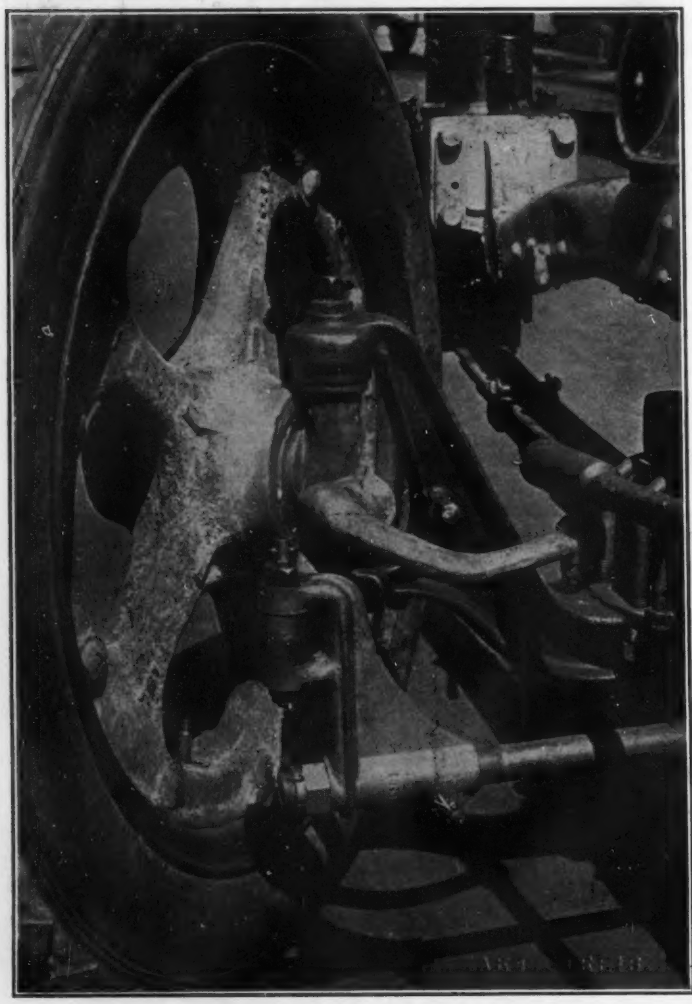


Fig. 17—A Special Form of Drop Steering-Knuckle
This Type of Knuckle Was Made Necessary by the Use of a Longer and Flatter Front Spring To Increase the Riding-Comfort Which Lowered the Frame

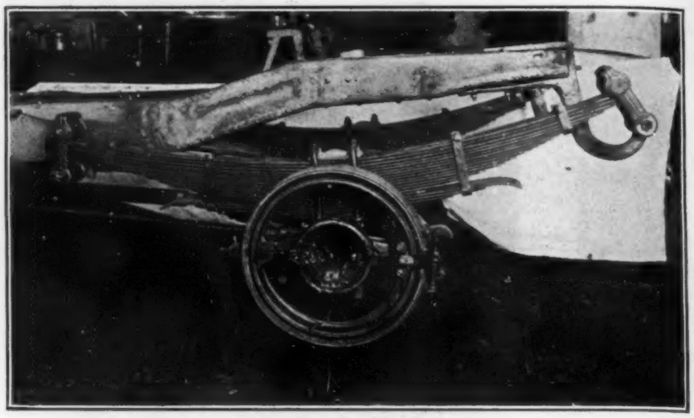


Fig. 18—Kick-Up at the Rear End of the Frame
This Construction Was Made Necessary by the Increased Depth of the Rear Spring and the Use of Over-Load Springs if the Height of the Floor from the Ground Was Not To Be Made Too Great

Development of Stages Expensive

Comparing the older types with the latest type of body, you will appreciate at once that one of the heaviest expenses of the stage and motorbus business in the past has been caused by the obsolescence of body types, that is, abandoning bodies that are in first-class condition to meet the demands of the public and keep up with the advances in the art. This is an expense that cannot be avoided until the rapid development of body types is over. Next to this, is the cost of making-over chassis purchased from the factory; and, thirdly, the cost of maintenance.

Unlike obsolescence, this reconstruction cost and its attendant high maintenance-cost should be eliminated. They arise from the fact that a stock chassis turned out by the manufacturer is primarily a freight unit and must be modified to meet the local conditions of passenger service. One modification usually involves another; for instance, putting in a longer and flatter front-spring for greater riding-comfort lowers the frame and requires the lowering of the steering-knuckles, as shown in Fig. 17. Increasing the depth of the rear spring and using overload springs involves "kicking-up" the rear end of the frame to avoid increasing the height of the floor of the car above the ground. This is illustrated in Fig. 18. Front axles are not proportioned in accordance with the passenger load. An example of such an axle and the manner of reinforcing it are shown in Fig. 19. Radiators that are satisfactory on one line are too small on others. So it goes.

Annual maintenance costs on rebuilt cars amount to more than 60 per cent of the cost of the equipment when new. This, in time, will become lower, when we get a more uniform standard and a longer life of the wearing parts. But, with factory-built equipment that is suited to stage service, rebuilding will be unnecessary.

The Future Source of Equipment

The industry cannot be required much longer to buy stock chassis from the factory and alter them to suit the service in which they are to be placed, yet no one manufacturer turns out a chassis complete for all purposes. The stage business has advanced greatly but, as stated in the opening paragraphs of this paper, has not nearly reached a standardization of equipment; and, if we do not join in more constructive cooperation, we shall come to a parting of the ways between the manufacturer and the consumer.

The need of the West is capable manufacturers that can be relied on to stay in business and keep up with the times, so that an operator can standardize on a product

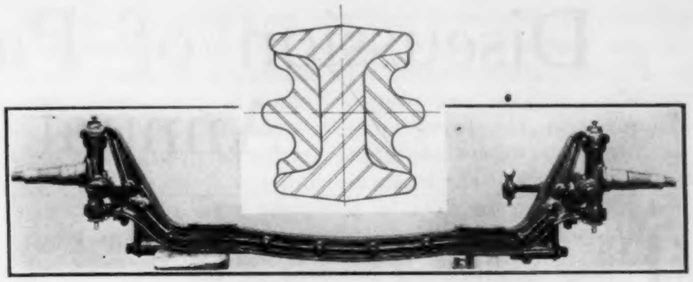


Fig. 19—Front Axles Are Not Proportioned To Carry the Passenger Load
This View Shows a 2-Ton Front Axle Reinforced To Carry a 25-Passenger Load. The Reinforcement Is Shown in the Small Drawing

for his fleet without fear of becoming an "orphan" and can carry a stock of parts sufficient for his maintenance for only a reasonable period. Second, the manufacturer must furnish what can be used in the service; or, if the need is so special that this is not feasible, he must be willing to sell only the parts that can be used, so that the purchaser will not be required to take off new wheels, springs or other parts and replace them with others that he needs and, in the meantime, be seeking a market for the parts removed and accepting a price much below their actual value.

If the industry cannot get this service, it will be obliged to develop assembling plants of its own and contract with A for engines, with B for transmissions, with C for frames, and so on, assembling the units into the final equipment that is suited to the requirements of the territory. Some stage-systems on the Pacific coast are so close to doing this now that it would not take much additional investment to give them complete assembling-plants. It will depend on the manufacturers whether these assembling-plants will grow or whether the manufacturers themselves will furnish a product to meet the passenger service, irrespective of whether the product can also be used successfully as a freight unit.

EXHAUST GASES FROM A GASOLINE ENGINE

The gases from a gasoline engine are poisonous unless greatly diluted with moving fresh air. However, these gases, when properly diluted, become harmless. The exhaust from a gasoline engine is a mixture of gases, some harmless and some dangerous. The most dangerous is carbon monoxide. Carbon monoxide is the product of burning carbon without enough air. One part of carbon monoxide in 1000 parts of air may be breathed for short infrequent intervals of time without discomfort or danger, but 1 part of this gas in 500 parts of air may cause severe headache after it is breathed a short time. A little more carbon monoxide may cause unconsciousness and finally death.

If the engine and its carbureter are in perfect adjustment, only enough gasoline will be burned with a proper amount of air to produce the power needed, and little, if any, carbon monoxide will be given off. However, if all adjustments are not perfect, too much gasoline is burned and the exhaust contains considerable carbon monoxide.

The presence of a dangerous amount of carbon monoxide in the exhaust can be detected only by special tests. The gas is colorless, odorless and tasteless. It is extremely poisonous, because it combines with the red coloring matter of the blood more readily than oxygen does, and blood that is saturated with it cannot take up oxygen. Exposure to an atmosphere containing only 0.20 per cent will cause a man at rest to collapse within 1 hr., and exposure to as little as 0.05 per cent causes headache in several hours' time. Various people are affected differently, and a man at work will be overcome much more rapidly than a man at rest. The dangerous symptoms come almost without warning.

When gasoline is burned in the presence of enough air the carbon is almost entirely converted into carbon dioxide and the hydrogen into water. If, however, the amount of air is not enough, besides carbon dioxide and water, carbon monoxide, hydrogen and methane are formed. As these three gases are all combustible when mixed with air, their presence in the exhaust represents waste. The carbon dioxide is at its maximum when 2.5 per cent of gasoline vapor is contained in the mixture prior to combustion. From that point the carbon dioxide decreases and the carbon monoxide begins, the latter reaching its maximum at 4.1 per cent of gasoline vapor. The range of complete combustion is very narrow, between 1.5 and 2.5 per cent, so that it is almost impossible to run an engine without producing carbon monoxide at times. Watson has shown that carbon monoxide begins to form with mixtures of 14 parts of air by weight to 1 of gasoline and increases to about 12 per cent at 9 parts of air to 1 of gasoline. These results are comparable to those obtained by Burrell and Boyd in their experiments, for Watson's first mixture is approximately 2.5 per cent and the second 3.7 per cent.

An automobile engine should not be run in a small garage unless the doors and windows are wide open.—From Bureau of Mines Technical Papers 174 and 2160.

Discussion of Papers at the 1924 Annual Meeting

THE discussion of the papers presented at the Body Engineering Sessions of the 1924 Annual Meeting is printed herewith. The authors were afforded opportunity to submit written replies to points made in discussion of their papers.

For the convenience of the members, a brief abstract of each paper precedes the discussion, with a reference to the issue of THE JOURNAL in which the paper appeared, so that members who desire to refer to the complete text as originally printed and the illustrations that appeared in connection therewith can do so with a minimum of effort.

Publication of the discussions at the 1924 Annual Meeting is now complete.

RUST RESISTANCE OF NICKEL-PLATED STEEL

BY EDWIN M. BAKER[1]

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

THE quality of plated steel may be tested by exposing the article to the action of a salt spray and noting the appearance at intervals. A numerical method of rating the appearance is presented, and the rust resistance of steel plated with nickel and copper is shown to be dependent on the thickness of the plating. The effect on the salt-spray resistance of some common variables in nickel-plating, such as boric acid, ferrous sulphate, current density and defective steel, is disclosed and charted. The need of close technical control of the plating process is indicated, and some of the advantages of controlled electroplating at high current-densities are set forth.—[Printed in the February, 1924, issue of THE JOURNAL.]

THE DISCUSSION

E. BOUTON[2]:—Has application for a patent on the process been made?

E. M. BAKER:—Yes.

MR. BOUTON:—With reference to the radiator shell, is the plating that results from the duplex method more durable than that resulting from the cyanide process? Is the duplex method more economical?

MR. BAKER:—Several factors must be considered. The duplex, or nickel-copper-nickel, process, using an acid copper-plating solution, is easier to control; the cyanide-copper process is somewhat more complicated and harder to control from a laboratory standpoint. One objection to the cyanide-copper process is the peeling of the copper from the base metal. That, I think, is not necessarily an objection, because cyanide copper can be made to adhere; also, I believe, in plating with cyanide copper the plate can be deposited so that it will stay on fairly well when the metal is not entirely clean. The plating is good enough to pass inspection, whereas, with the nickel coating, if the metal is not thoroughly clean, the plating will peel easily at once. That is perhaps an advantage. Copper deposited from a cyanide solution is fine-grained and nothing is fundamentally wrong with such copper. We are plating with nickel, copper and nickel, using an acid copper-plating solution, and find it possible to deposit the metal smoothly enough, so that, even with a total plating that exceeds 0.001 in. in thickness, it is necessary to buff the final coating only. I know of no instances in which any better results than these are obtained with the cyanide-copper process.

MR. BOUTON:—My understanding is that, with the cyanide-copper process, a very high polish must be attained before the copper-plate is applied and that, with the duplex method, the polish does not need to be so smooth; in other words, a coarser-grained emery can be used, but a heavier coat of copper is needed to give the desired finish to the nickel. The surfaces can be evened up with a little more copper, buffing them afterward, perhaps; then the nickel coat could be applied. That would be much more economical, because a saving would be made on the polishing operations; the buffing-leather cost would be less and not so many operations on the various wheels would be necessary. It would not require so skilled a polisher. An ordinary laborer could do as good polishing as a skilled polisher does in the cyanide-copper process.

MR. BAKER:—Yes, it is possible to put on a very heavy coat of copper and to buff that down; the copper, being, as the men in the shop say, "somewhat soft," will smear around through the scratches. Where nickel is deposited and then a heavy coating of copper, and the copper is buffed, considerably less polishing is needed to start with to produce a good finish. Even when nickel, copper and nickel are deposited in sequence, buffing only the final plate of nickel, some of the scratches may be eliminated, though the coarser scratches will still show. The questions of the first polish and the cost of the final buffing enter in a sort of mutual function; that is, the better the product is polished at the start, other things being equal, the less effort will be required in buffing. In other words, a certain degree of polishing represents the lowest average cost.

T. J. LITLE, JR.—What about chromium-plating for rust prevention on steel?

MR. BAKER:—Chromium is an ideal metal in many ways; it is on the right side, electrolytically, to protect metal from galvanic action. Unlike zinc and cadmium, when exposed to the atmosphere, it does not itself become of poor appearance on a polished surface. Zinc and cadmium will corrode to a dull white, which would be objectionable on a lamp rim or an article of that

[1] Assistant professor of chemical engineering, University of Michigan, Ann Arbor, Mich.

[2] M.S.A.E.—Supervisor of time-study, Chandler Motor Car Co., Cleveland.

sort. Chromium-plating has been described in some recent papers of the American Electrochemical Society. I am not aware that it has been reduced to any good standard practice. The current efficiencies cited were around 30 per cent, using current densities of between 100 and 200 amp. per sq. ft. To get those current densities would require high voltages, and something like a total of 10 times the electrical energy that would be necessary to put on the same weight of nickel or copper. I imagine that these difficulties will be reduced in the future. I heard that one plant in the East was depositing chromium on some drills to harden the edges. It is a metal that is rather difficult to deposit with any great degree of satisfaction.

MR. LITLE:—Fundamentally, is chromium a much better metal for the protection of steel?

MR. BAKER:—Fundamentally, it is fine for the purpose. The question is one of practice in operation.

H. D. WILSON:—What is the nature of the improvement in the process that makes it patentable?

MR. BAKER:—It relates in general to the combination of steps and the use of high-current densities.

W. H. GRAVES:—I realize that the main benefit is the advantage obtained from better nickel-plating, that it does not rust when it gets onto the surface. Is that due to the nickel-copper platings or to the final nickel put on?

MR. BAKER:—In the first of the general curves shown in my paper, having thickness of plate as ordinates and rust resistance according to the salt-spray rating as abscissas, there were combinations of constant total thickness ranging from very thin first-coats to very thin final-coats and of thin to thick coats of copper and, in some cases, of a number of alternate coats; that is, of very thin coats of nickel, copper and nickel. Generally speaking, the difference was not great. If, however, the intermediate or alternate coats are made very thin, apparently there is not only no particular advantage but a coat made up of a sequence of a great number of thin coats applied one over the other may afford considerably less protection than a coat of two or three layers. Nothing is gained by carrying the process of excessive coats to extremes; in fact, an actual loss occurs. Besides, a great number of coats would be tremendously expensive from the operating standpoint.

W. R. CUSAC:—What has been your experience with zinc as an undercoating?

MR. BAKER:—I have not had much experience with zinc. We made a number of experiments and examined the results. In the salt spray, the general breakdown causes first a white coating or corrosion product that comes out as a white incrustation. We think that this incrustation is fully as bad a condition as rusting; it is accompanied ordinarily by extensive rising up and breaking of the actual nickel-plate, commonly known as "blistering." The objection to having the zinc underneath is the difficulty of subsequent plating; the possibility of a high percentage of rejections is great. Zinc is a sort of trouble-maker. Unless it is very thick, any coating will permit rusting in time; the slow process of corrosion eventually will consume the protective coating.

CASEIN GLUES FOR AUTOMOBILE-BODY ASSEMBLY

BY W. A. HENDERSON[3]

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

CASEIN glue is prepared from the solid part of skimmed milk. After it has been precipitated by acids or bacteria the casein is pressed, broken into small particles, trayed, dried, ground and bolted. The complete removal of fats is essential in casein that is to be used for glue. Adding a small percentage of hydrated lime forms calcium caseinate, an insoluble compound. Although this tends to harden the glue, it reduces the adhesive power and is very destructive to edged tools. Casein glue sets partly by evaporation and partly by chemical action.

Most casein glues are heavy and spread less readily by hand than does animal glue, but that now being made for the automobile-body trade has overcome this difficulty; when a glue-spreader is used, casein glue will cover a greater area than an equal amount of animal glue.

The uncertainty of getting a good joint with animal glue, because of variations of the temperature of the room and of the wood and the composition and freshness of the glue, is obviated in casein glue, which may be mixed at any time in the correct proportions, requires no further attention, yet retains its maximum sticking properties. It may be used at temperatures below freezing on cold wood and the pieces may be allowed to stand for 20 min. before being clamped or screwed. It is highly water-resistant; when applied to a three-ply panel the glue can be boiled without the plies separating. Heat does not weaken the glue but, on the contrary, strengthens it. One of the great advantages of its use in automobile bodies is the fact that it is quickly and easily prepared and thereafter needs no further attention; any portion that is left over at night is poured into the new mix the following morning.

[Printed in the February, 1924, issue of THE JOURNAL.]

THE DISCUSSION

H. G. BERSIE:—How long has this new glue been available? What companies use it in the framing work on automobile bodies?

W. A. HENDERSON:—It has been available for a few months. Among the companies that use it are Durant Motors, Inc., the Star Motor Co. of California, the body company that manufactures the body parts for the Durant, the Flint, the Chevrolet and the Dort cars and for Biddle and Smart. In fact, most of the custom-shops use it, such as Brewster & Co., Long Island City, N. Y., and Locke & Co., New York City.

H. C. MOUGEY:—Regarding the heat-resisting properties, if casein glue were used in a body having a wood-frame construction, would it be possible to bake black enamel on the body at high temperature just as though the body were of all-steel construction?

MR. HENDERSON:—Yes, up to a temperature of 350 deg. fahr. The glue would not have its complete strength immediately after being removed from the oven but, after standing in a normal temperature, it will attain all of its strength. The joints must be reasonably well made if extreme heat is to be applied.

[3] Casein Mfg. Co., New York City.

W. H. GRAVES:—How long must work glued with casein glue be left in the clamps? If unclamped after 4 or 5 hr., would the work be as strong as if glued with hide glue?

MR. HENDERSON:—All plants that have adopted casein glue continue the regular shop-practices that they had been using with hide glue; they take the clamps off after from 1½ to 2 hr. The casein glue does not then possess its maximum adhesiveness, but it has strength enough to allow the manufacturing process to be continued.

C. L. PFEIFFER:—Please describe the chemical composition and the nature of casein glue. How does it react with water?

MR. HENDERSON:—Casein, which is the solid part of skimmed milk, is the main ingredient. The quality of the glue depends upon the quality and the process of manufacture of its ingredients. A small percentage of lime is combined with the casein to produce calcium caseinate, which is insoluble. Added to this are a number of other chemicals that control the liquid life of the glue, its drying properties and the like. The early casein-glues contained large percentages of lime, which not only reduced the adhesive strength of the glue but made it very hard on edged tools. The modern body glues contain merely sufficient lime to create a chemical action.

GEORGE KLICKS:—Does casein glue penetrate to the same extent as animal glue?

MR. HENDERSON:—It does penetrate but not to the same extent.

MR. KLICKS:—What is the depth of penetration?

MR. HENDERSON:—That depends entirely upon the porosity of the wood. I have sized chestnut over on the end grain and then split it; the glue had penetrated an average of ¼ in. I believe it will penetrate ash nearly as much; oak, a little less; and maple, much less. Inasmuch as casein glue does penetrate, if the glue is put on and let stand for about 1 min., rather than to clamp it immediately, a better joint will result.

MR. KLICKS:—On a planed surface the penetrating property is really what makes the animal glue stronger in glued-up blocks or in test-specimens. Will casein glue hold on a painted as well as an unpainted surface?

MR. HENDERSON:—It will hold many times better than any hide glue on a painted surface. With thinned casein-glue you can glue linoleum to a wood running-board that has been dipped in creosote, without putting any weight on the linoleum. When you tear the linoleum off, some of it will be left on the wood.

MR. KLICKS:—You call it a cement.

MR. HENDERSON:—No, I say it is a glue-cement. It has the properties of both a glue and a cement. It is neither wholly a cement nor wholly a glue.

MR. KLICKS:—If it had the proper characteristics, paint should not affect it.

MR. HENDERSON:—There is a casein glue that can be used on a painted surface, but it is a quality of glue that dulls edged tools. With that glue, you can glue iron to wood or aluminum castings to wood.

MR. KLICKS:—What is the cost of casein glue, compared with that of animal glue?

MR. HENDERSON:—The casein glue that is being made for the body industry sells at 20 cents per lb. up to a quantity of 2000 lb.; for a greater quantity, the price might be lower.

MR. BERSIE:—Does the casein glue in which the lime-content has been reduced last as long as other casein-glues?

MR. HENDERSON:—Age does not interfere with casein glue at all. Ancient Egyptian cabinet-makers used casein glue that is still holding well.

R. A. LABARRE[4]:—At the time we were building airplanes, we used waterproof glue on a quantity of veneer. Our greatest trouble was in the cutting of the material, only about ⅛ to 3/16 in. thick. After cutting a few piles of thin wing-webs we had a saw-edge on the shaping-machine knife. Being skeptical about this new casein-glue, we glued up numerous samples with it for testing. One of them was poplar, about 2 ft. long. We glued up about eight pieces sidewise and, after they had set for about 24 hr., we sharpened the jointing-machine knife and then set this block up against the gage so that it would always follow the same path. We ran the block across the jointing machine about 24 times and found that knife in exactly as good condition as it was in before we began the test.

W. R. CUSAC:—Does casein glue have a deteriorating effect upon linoleum or any painted surface?

MR. HENDERSON:—Not to my knowledge.

MR. CUSAC:—Is it not of an alkaline nature?

MR. HENDERSON:—Yes, because it contains a percentage of lime, but this percentage has been reduced greatly in modern casein-glue for body work.

TRIMMING MATERIALS AND STYLE

BY H. T. STRONG[5]

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

WOOL is the short-staple fiber taken from the fleece of a sheep; worsted is the long wiry fiber combed out of the wool and put through a different process of spinning; all mohair comes from the long-haired Angora goat. Formerly every man wore woolen clothing; now he wears worsted, because it wears better, does not hold the dust and stays in shape better. Worsted has been largely adopted for automobile upholstery for the same reasons, and because it has a resale value not surpassed by any other material.

So great a degree of perfection having been reached in mechanical construction and in the beauty of the exterior lines of present-day cars, more attention, in the opinion of the author, should be devoted to beautifying their interiors. The pendulum having swung from the extremely garish and ornate to excessive plainness, the question is asked whether the time for the return-swing has not come, for sales reasons that are realized by other industries; and suggestions are offered regarding improvements that might be made.

The fallacy of buying low-grade carpets is shown, a saving of $1 per yd. sometimes causing an expenditure of $10 for new carpet within 2 or 3 months, whereas the better carpet would have lasted 2 years. Brussels horse-hair carpet is often purchased for phaetons and velvet or Wilton weave for closed-car work.

When buying carpets the count of the sample should be inspected. This can be done readily by a counting-

[4] M.S.A.E.—Chief engineer, Towson Body Co., Detroit.
[5] William Wiese & Co., New York City.

glass. A quotation honestly submitted on a sample of carpet should be accepted; for if the price is forced down it is likely that reworked wool, or shoddy, will be used that will give a poor wearing surface, although the difference will not be apparent until the carpet is put into use.

In curtain silk, on the other hand, the substitution of fine Sea Island cotton for silk will increase the wear; in very low-priced cars mercerized all-cotton fabric is preferable. Perfect all-silk fabrics are difficult to secure, because of the fact that the strands, which usually consist of eight filaments, sometimes contain nine, sometimes only six or seven, and also because the filaments from healthy cocoons are a little larger than those from cocoons not so healthy. For medium-priced owner-driven cars of the sedan or coupé type hard-wearing durable dark-colored fabrics are recommended, while for the more expensive types face-finished broadcloths or soft suede, or velure-finished woolen fabrics of lighter and more artistic colorings, are to be preferred. More attention should be given to instructing salesmen regarding the reasons for selecting particular fabrics.

As only 2 per cent of the selling price of a car is expended for upholstering materials, and as the final decision as to the selection of a car is usually left to women, it is important that the impression made when the car door is first opened should carry an appeal for ownership.

Care should be taken to see that fabrics maintain the quality of the sample. Various devices are described by which this may be done quickly. These include an improved hand-operated cloth-tester for determining the warp strength and the filling strength, a cloth-sampling scale by which the weight per running yard can be ascertained simply by weighing a small sample, a Fade-Ometer for determining the quality of the dyes, a counting-glass for counting the number of threads in all kinds of fabric, a boiling-out outfit for testing the proportions of wool and cotton in the material and daylight lamps for examining the color and finish. [Printed in the April, 1924, issue of THE JOURNAL.]

THE DISCUSSION

H. T. STRONG:—I believe that more sales of $4,000 or $5,000 cars would be made if a lap-robe were hung over the robe-rail as part of the equipment of the car. A lap-robe can be furnished at almost any price desired, made with a face of exactly the same material with which the car is upholstered, and lined with a plush of any desired grade. Such a robe would cost say $40 to $45 for a $5,000 car; perhaps less than that if bought in quantities.

For boiling out cloth to determine how much cotton and how much wool it contains, a small bowl and a solid-alcohol heating-outfit will indicate exactly how much cotton has been used in a piece of fabric. A solution of caustic soda is employed. It will dissolve all the wool, but has no effect on the cotton. A quick method of testing for cotton in wool cloth is to burn threads of the cloth. A cotton thread will burn quickly; a wool thread will burn, but it leaves a long trace of black ash.

A machine for testing the materials used for warp threads and for filling threads is needed also, as well as cloth-weighing scales. I believe every properly equipped factory should have all these conveniences either in the body engineer's or in the purchasing agent's office.

QUESTION:—How can water-spots be taken out?

MR. STRONG:—Only one way to remove water-spots from cloth exists; it is to raise the nap all over the piece and make it even. Water-spotting is caused by the rising of the little fibers that have been ironed down when finishing the cloth. To remove water-spots from a door, take a heavy piece of cloth, soak it in water and put it over the entire door; then use a heavy iron that has plenty of heat in it and iron the entire door. This process will raise the nap over the entire surface; when the material becomes perfectly dry, the water-spots will have disappeared.

QUESTION:—Does this process apply to worsted as well as to wool?

MR. STRONG:—No. Worsted is a type of fabric that has not a face-finished surface. A fabric like broadcloth will cause the greatest amount of trouble from water-spotting because it has an artificial finish, which gives it its high luster.

G. W. KERR:—Will a piece of cloth that has been sponged water-spot?

MR. STRONG:—No, because that raises the nap; but a piece of cloth that has been sponged does not retain its luster.

AUTOMOBILE UPHOLSTERY LEATHER

BY K. L. HERRMANN[6] IN COLLABORATION WITH FRANK J. RADEL[7]

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

FIRST referring to a bulletin that lists the natural defects of hides and gives hide classifications, the authors explain many of the technical terms used in leather manufacture and present an illustrated detailed description of the process by which a hide is transformed into upholstery leather suited for automobile use. The defects are technically known as grubs, brands, wire scratches, knife-cuts, scores and hair-slips, and their influence on the finished product is stated; then a hide is followed through the different stages of its transformance into leather from its green salted state.

After opening the bundles of hides and trimming from them the heads and the long shanks left on by the packer, the tanner puts each hide through the several processes of beaming, liming, unhairing, fleshing, deliming, tanning, splitting, re-tanning, sumac treatment, wet-tacking, shaving, softening, patching, japanning, doping, swelling, embossing and graining. Detailed control of all these is essential and is accomplished mainly by special machines and through utilizing the practical knowledge acquired by the operatives.

Difficulties attendant upon preparing a satisfactory leather specification are stated and a method of patching hides is mentioned that, it is expected, will be productive of large savings for the tanner and for the automobile builder. Hide shapes and cutting losses are discussed also and improvements in practice are recommended.—[Printed in the March, 1924, issue of THE JOURNAL.]

THE DISCUSSION

HERBERT CHASE:—Is the No. 1 split, shown in Fig. 9 of the paper, the same on both sides?

[6] M.S.A.E.—Assistant manager, Studebaker Corporation of America, Detroit.

[7] President, Radel Leather Mfg. Co., Newark, N. J.

K. L. HERRMANN:—Yes. The buffing taken from machine-buffed hides is only 1/64 in. thick and the sanding or snuffing of full-grain leather also removes some material; so, when we reach the No. 1 split, it becomes more a matter of the quality of the original hide and tannery details. The split under full-grain leather, snuffed, is just as good as the one under machine-buffed leathers.

MR. CHASE:—Is this patching done before the hide is coated?

MR. HERRMANN:—Yes.

CHAIRMAN L. C. HILL:—The recommendation on upholstery leather specifications that Mr. Herrmann and his Committee have prepared are included in the Standards Committee report printed on p. 44 of the January, 1924, issue of THE JOURNAL. I particularly commend that report to purchasing agents.

C. L. PFEIFFER:—Do these patches test all right on the testing machine?

MR. HERRMANN:—Yes.

MR. PFEIFFER:—They do not show at any particular place?

MR. HERRMANN:—They are stronger through the joint and seam end than they are in the natural leather.

GEORGE W. KERR:—This investigation seems to have led to some astounding conclusions. With due regard for Mr. Herrmann's efforts, one of the conclusions seems to be that now the bottom split is better than the grain side of the leather. The other conclusion is that now grubholes constitute no defect. Those of us who have used leather for more than a quarter of a century know from experience that hand-buffed grain-leather will outlast any kind of a split, with any kind of a process that you can use on it. That the bottom split is better seems a very questionable conclusion to put forward as the result of this investigation. Other points exist concerning the durability of leather than the mere withstanding of a mechanical test for strength, such as its ability to take finish and the like. If it were true that the grain side of the leather is not the best portion of the leather, why would not the people who are anxious to buy the buffings have the hide all split into buffings? I think that conclusion should not go on record as being the final result of this investigation, without having subjected it to further discussion.

MR. HERRMANN:—We did not expect this conclusion to be accepted in its entirety. We realize that it is radical and contrary to practice, but our specification has not included any of this radical part. The point is merely brought up for the purpose of having automotive engineers think along those lines and help us to build up further specifications from those that we have. In the matter of preparing specifications, we must get into the field from a somewhat different angle, and it is hoped that those who can will conduct experiments, confirming or disproving the things we have found. We have, however, made a sufficient number of tests to know that the chances are 99 out of 100 that we are right; otherwise we would not present these findings. The thoughts we have outlined are not acceptable to the trade today. It is a matter of spreading the information so that each interested person can make these tests and convince himself of the result.

The fact that the inside of the hide is the best has been known for many years, but it has not been applied to the upholstery-leather business. It may never be applied. We did not discuss a number of things that have still to be developed further, but this can be said: We know two tanners who can tan the inner split so that it feels the same as the hand buff and lasts three times as long; that is, comparing it with their own hand-buffed leather.

QUESTION:—Did the Committee determine which method of tanning is the best; that is, bark tannage, acid tannage or chrome tannage, as carried out in this investigation?

MR. HERRMANN:—All we want is to get the tanners and the Tanners' Council to work out this problem. We do not care how leather is tanned. If the tanner finds he can produce a better leather to meet these specifications by using hemlock or sumac or oak, that is his problem; we do not intend to go into that at all. What we do intend to do is to help the tanner all we can. The tanners did not appreciate that intention and some of them do not yet appreciate it.

QUESTION:—Two recognized methods exist for splitting leather, the union machine and the hooker knife. Which is the proper or better method?

MR. HERRMANN:—We do not care on what kind of machine a leather is split, so long as it is uniformly thick. We cannot use a hide that may be $2\frac{1}{2}$ oz. in one spot and $3\frac{1}{2}$ oz. in another. A hide ought to be fairly uniform.

QUESTION:—Did you determine which coating is the best to put on leather to keep it pliable and to prevent it from cracking? And what the troubles are that the automobile industry experiences in using leather?

MR. HERRMANN:—The coating is another subject for later consideration. We have undertaken as much as we dare, now. At present, the situation is too complex for us to specify the number of coats and the amount and kind of material to go into each coat. We trust that eventually we can gather sufficient information to prepare a specification. We are not interested so much in what the coating consists of and how it is applied as we are in what the coating will do in actual service; most motor-car manufacturers do not care whether the coating is made up of linseed oil or dope, so long as it sticks, and stays on and produces a good durable leather.

QUESTION:—Does any option exist as to the amount of chrome tanning?

MR. HERRMANN:—Chrome tanning has just as many defects as the other processes. We find that a good bark-tanned leather fulfills our requirement. It does not need to be an unusually strong leather to outwear the car. Chrome tanning is no doubt good, especially when very severe usage is to be given the leather. However, the difference between various hides in the chrome tanning has been too great, just as considerable difference has been found in hides tanned by other processes. The important thing is uniformity of product, rather than the particular process of tanning.

MR. CHASE:—The question has been raised as to what will happen in practical service with the upholstery material that is made of the first or second splits. Has not the Committee already made some tests in actual service over a considerable period? The results may answer that query in part.

MR. HERRMANN:—We have made numerous tests in service; however, we have worked only a short length of time on the subject. So far, the cars that were equipped with this leather have proved more satisfactory than the cars equipped with the hand-buffed leather. It is too early yet to say just exactly how the matter will work out. I would rather await developments for another year or two. Not everything we did was successful. We may discover something that is not right yet; but we are working along these lines and desire to have all car-

builders try out some of this material in any way they see fit and report upon it.

A MEMBER:—I have fought for 30 years trying to get engineers to put the hair side of leather belting next to the pulley because the friction surface is greater, but I have never been able to get more than half of them to do it. Wear of automobile upholstery is due to friction. We do not need great tensile-strength. If, say, 1/16 in. of the hair side of a leather belt is shaved off, it can be broken with the fingers, but if 1/16 in. is shaved from the flesh side, it cannot be broken with the fingers. This shows that the latter is stronger, but does not prove that it wears better. That is my point. You have never seen a double leather-belt that did not have both sides haired. This is the proof of its superior wearing quality.

MR. HERRMANN:—It is admitted that if 1/16 in. is taken off the hair side, it has no strength and cannot be used for belting; but if the next 1/16 in. is taken off, it is found to be a pretty good piece of leather. The hair side of belts is left on for appearance.

CHAIRMAN HILL:—No progress will be made by the automotive industry so long as we say that, because some certain thing has been done in the same way for many years, it cannot be done any better. I believe that we can improve leather by cooperation of the type adopted by Mr. Herrmann's Committee. Constructive thought on leather manufacture and leather specifications will surely lead to improved methods.

WILLARD C. LIPE

A PIONEER in the gear-manufacturing industry, Willard C. Lipe, vice-president of the Brown-Lipe Gear Co., of Syracuse, N. Y., died, Sept. 4, 1924, aged 62 years. He was born in 1861 at Fort Plain, N. Y. In 1883 he was graduated from the Clinton Liberal Institute. His first business venture was that of the manufacture of bicycles; later, automobile transmission and differential gears were added as products.

When the Brown-Lipe Gear Co. was formed, about 1895, Mr. Lipe's active duties were those of manager and designer. He also was a designer and builder of special machinery, gears and tools. He was the designer and patentee of an automatic broom-sewing machine for the Lipe Walrath Co. of Syracuse, having served as president and general manager of that company. He designed and patented roller bearings for car axles, and in 1917 was president of the Railway Roller Bearing Co., in Syracuse. Both Willard Lipe and Alexander T. Brown were associated also with the Brown-Lipe-Chapin Gear Co. from 1910 to 1922.

Mr. Lipe was a member of the Technology Club of Syracuse. He was elected to Member grade in the Society, Nov. 12, 1917.

This greatly lamented member, who contributed much of value in the field of the Society, was one of the most appealing figures in the industry. He was a whole-souled man of great simplicity and personal charm. During the World War he not only took a conspicuous part in the designing of the transmission for the Class-B truck, but worked on the drafting-board in the many studies that were made. This friend is deeply and widely mourned for what he accomplished in industry and for what he personified in manhood and character.

OSCAR A. SMITH

ON Aug. 20, 1924, an automobile in which officials of the National Acme Co. of Cleveland were riding was hit by an express train near Painesville, Ohio, and Oscar A. Smith, superintendent of the screw-products division of the company, was killed instantly. The vice-president and general superintendent of the company, Edwin C. Henn, died shortly after.

Mr. Smith was born, Sept. 7, 1871, at Meriden, Conn. In 1896, following his preliminary education and training, he became associated with Mr. Henn as an inventor and designer, the latter being then engaged in experiments leading to the design of a multiple-spindle automatic screw-making machine, and Mr. Smith was directly associated with Mr. Henn since that time.

Not only did Mr. Smith have an important part in the design of the original Acme automatic screw-making machine, but he also was instrumental in designing many of the changes made in the later types of this machine. In addition he patented, in his own name, a score or more of ideas dealing primarily with secondary operations such as bolt and stud threading, multiple-spindle drilling and the like. He was elected to Member grade, Sept. 15, 1921.

CHARLES J. RINALDI

IT is with regret that we record the untimely death on Sept. 1, 1924, of one of the Junior Members of the Society, Charles J. Rinaldi, aged 21, a student in the Massachusetts Institute of Technology, Cambridge, Mass.

Mr. Rinaldi was born, Jan. 7, 1903, at New York City. Following his elementary education, he completed the technical course at the Stuyvesant High School. At college, he was registered in the course leading to the degree of mechanical engineer, with an option of specializing in automotive engineering. He had already contributed to engineering literature in articles published in *The Technology News* and also was a student member of the American Society of Mechanical Engineers. He was elected to Junior Member grade in the Society, March 13, 1924.

The Gasoline Railroad-Car for Branch Lines

By W. L. Bean[1]

Automotive Transportation Meeting Paper *Illustrated with* Photographs and Drawing

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

GASOLINE rail-cars for branches of trunk-line railroads and for short-line roads have been the subject of much discussion since 1920. Mechanical officers of interested railroads, the engineers of companies building highway motor trucks and others specializing on this subject have now developed designs to meet the different service requirements. Several hundred cars of various types have been built and are in service. The railroad with which the author is connected has in operation or on order 24 cars.

Consideration of several principal factors of design is necessary if a selection is to result in obtaining equipment suitable for the particular service requirements of the carrier and if the knowledge accruing from the engineering development and operating experience of the past several years is to be of value. Important factors include:

(1) Horsepower rating of powerplant in relation to car speed, weight, grades, curvature and operating schedules; especially in the case of internal-combustion engines the power must be sufficient to permit engine operation at speeds and outputs well within the maximum of the engine

(2) Type of transmission between engine and wheels; to be simple to operate, accessible for repairs, rugged for endurance, quiet in operation and efficient in power transmission

(3) Single-end versus double-end control; the former is far preferable if terminal conditions permit, because it is cheaper to build, more reliable, has less weight and is easier to operate

(4) Distribution of available space between engine room, baggage room and passenger compartment. This factor is largely variable according to the ideas and the needs of the carrier. However, the convenience, comfort and safety of the passengers and the convenience of the crew require consideration because of the space available and the permissible weight

(5) Materials of construction are important and largely different from those usual in railroad equipment construction. Care is necessary to give lightness, strength, warmth, good appearance and quietness of operation at a permissible cost. Climatic conditions should be considered, as well as the more or less exacting requirements of the particular service

(6) Design of the car frame and body and of the trucks to give strength, lightness, good appearance and safe and quiet operation needs careful study and departure largely from usual steam-road practices

(7) Heating, signaling, lighting, ventilation and braking are all important factors concerning which experience has produced much information

(8) Multiple-unit control may be of some importance in later developments for specialized service but does not appear to be of considerable moment

The author has endeavored to give as much information from his own experience on these subjects as possible to help those railroad men and automotive engineers actively interested in the design of rail-cars to reach conclusions as to the best design of rail-car.

WHEN an engineering officer of a railroad undertakes the selection or design of a unit rail-car, he must consider carefully the factors of size of car, speed, grades, curvature, power of engine, transmission and control system, gear-ratio, heating, lighting and seating arrangement.

General Body Design

The size of the car, covering seating, baggage, express and mail capacity, saloons, if any, and engine room, as well as space for the engineer or the operator, should first be carefully determined. Because of the need for keeping the weight, and hence the powerplant to the minimum, the space design should not be liberal, but as small as practicable to meet the traffic requirements. Net economies diminish rapidly as the weight per passenger hauled increases.

Engines located inside the car bodies, especially in the case of the smaller cars, occupy relatively too much space to contribute to a design of the lightest weight. Hence, although the appearance may not be so attractive to the railroad man's eye, the shortening of the car body with the placing of the engine under a hood, along conventional automotive lines, is good from a weight-space utilization standpoint. Bulkheads or partitions dividing the car into several compartments should be as few as possible, because they add weight and also increase the awkwardness of passage through the necessarily narrow aisles and doorways.

The Engine and Its Horsepower

Having decided on the size of car body to give suitable seating and other capacity, the next things to determine are the size and the type of the prime-mover. The engine, it is presumed, will use gasoline fuel, since Diesel-type engines have not been produced and time-tried in light weights at horsepower ratings desired in passenger rail-cars of the sizes under consideration. Except in very small cars, it may be assumed that few four-cylinder engines will be used, because the amount

[1] M.S.A.E.—Assistant mechanical manager, New York, New Haven & Hartford Railroad Co., New Haven, Conn.

of power required is better supplied by six cylinders, with resultant quietness, smoothness and flexibility of operation. The use of two smaller engines on one car, with ensuing complications of control and regulation, weight, noise and vibration is not attractive.

In rail-car operation the brake horsepower demand for long periods of time in relation to the nominal rating of engine is higher than in highway-vehicle operation. The trend, as a result of experience, is toward larger power-reserve. To maintain railroad passenger-train schedules reliably throughout the varying seasons of the year, as is necessary to avoid serious complaints as to delays, especially for connections at junction points means that dependable power must at all times be available. Furthermore, it is not economical to require a gasoline engine to work continuously at high points on the horsepower curve to get plenty of power. Inasmuch as they operate largely on branch lines, gasoline rail-cars "tie up" at night or over Sunday at outlying points to which repair men must be "deadheaded," usually with resulting low labor-utility efficiency; consequently, if engines are overloaded and frequent repairs are necessary, the cost runs up. Ample power therefore is necessary to assure long life, low maintenance cost and dependability. That means engines large enough to give good power-reserve and to operate ordinarily at moderate speeds, well below what is permissible in other gasoline-propelled vehicles.

On the other hand, excess power is costly and therefore unwarranted. Determination should be intelligently made between the two extremes, including a review of the local conditions of any particular problem by someone who is sufficiently familiar with the engineering of the subject. The spread in power ratings is indicated in Table 1.

One feature not to be overlooked is the net horsepower available for driving the car, and that means the total horsepower of the engine less the demand of auxiliaries or "parasites," such as the fan or the blower, the air-compressor, the generator and any pumps or other apparatus requiring power. Under usual operating conditions this auxiliary demand will run about 10 or 12 per cent of the horsepower delivered by the engine. It is also necessary to consider the loss of power involved in the method of power transmission between the engine flywheel and the rail. The efficiency of the hydraulic system seems to be about 69 per cent; that of the gas-electric, about 72; and that of the geared car, about 80 per cent. For usual conditions of grade and speed, a loaded weight of car of between 300 and 400 lb. per total b. hp. is about right, depending on the transmission selected.

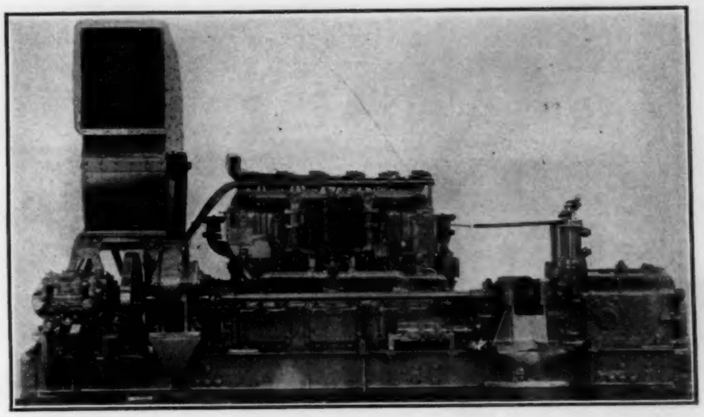


FIG. 1—POWERPLANT OF A MOTOR RAIL-CAR EQUIPPED WITH A HYDRAULIC TRANSMISSION

This Consists of a Six-Cylinder Internal-Combustion Engine with a 5⅝-In. Bore and a 7½-In. Stroke and Rated at 170 B. Hp. at 1200 R.P.M., a 100-Hp. Hydraulic Pump and Two 50-Hp. Hydraulic Motors That Are Connected to One Axle of Each Truck through Spur Gears. The Engine, the Pump, a Fan and an Air-Compressor Are All Mounted on a Common Bedplate as Shown

Six-wheel cars, driven by highway-truck-type engines, except for very limited use, seem to be out of the running. The eight-wheel car with a six-cylinder engine has taken the lead, since in the four-cylinder truck-type engine the horsepower and the permissible wheelbase with a rigid rear-axle are the limiting factors. This development has decreased the interest of motor-truck builders in the rail-car proposition, because it offers practically no outlet for standard parts production. Further, the demand for rail-cars will never favor anything approximating the quantity-production methods inherent in motor-truck construction.

TRANSMISSION SYSTEMS

Transmission systems, including the control, constitute the main consideration by all interested in the gasoline rail-car. The clutch-change-gear-propeller-shaft-system continues most popular because of its low cost, light weight, simplicity and dependability, largely because a demand for remote control, either in single cars or in multiple units, has not been great enough to displace single direction operation.

Hydraulic gear-shifting is a problem not undertaken on rail-cars, so far as I am informed, either by railroad engineers or by rail-car builders. It is an unfamiliar subject to railroad engineers and therefore a job for rail-

TABLE 1—ENGINE SIZES AND CAR WEIGHTS OF GASOLINE RAIL-CARS

Make of Car	Engine Rating, B.Hp.	Weight of Car, Lb. Light	Weight of Car, Lb. Loaded	Passenger Capacity	Loaded Car Weight per Brake Horsepower, Lb.	Type of Drive
Brill 55	68	29,000	36,000	38	530	Gears
Mack *AC*	64	23,700	31,300	35	490	Gears
Mack *AH*	140	57,000	65,000	52	465	Gears
Brill, New Haven	150	41,000	49,800	50	332	Gears
Sykes, New Haven	150	35,500	44,550	45	297	Gears
Brill 65	150	34,000	41,000	38	274	Gears
Brill 75	250	50,000	61,800	50	244	Gears
Sykes, Chicago Great Western[2]	225	39,000[a]	45,800[a]	30[a]	203[a]	Gears
		22,000[b]	28,600[b]	44[b]		
		61,000[c]	74,400[c]	74[c]	330[c]	
New Haven, Hydraulic	170	52,800	64,100	[illegible]	378	Hydraulic
New Haven, Brill-Gen'l Electric	225	70,000	81,150	[illegible]	361	Electric
General Electric (Old Type)	200	107,000	124,200	[illegible]	621	Old type electric

[2] Two-car train.
[a] Power car.
[b] Trailer.
[c] Train.

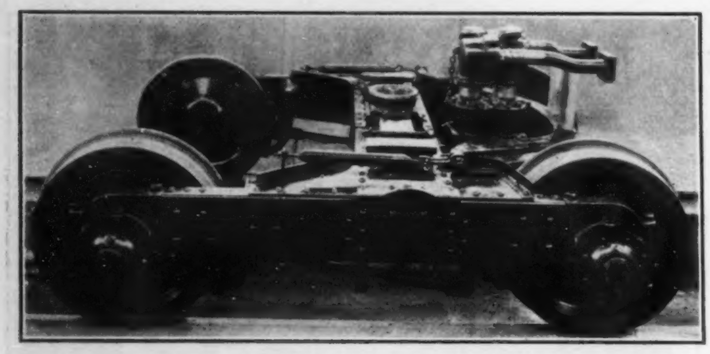


FIG. 2—SIDE VIEW OF A TRUCK
This Illustration Shows the Hydraulic Motor Mounted in Place at the Right with the Supply Pipes Projecting to the Right

car promoters to develop and sell to railroad men, if it possesses any merit. Electro-pneumatic control has had some attention, but it sounds complicated to the railroad man, who, from experience, prefers simplicity in design. Extra weight and cost also are factors. It is predicted that it will be something of a job to "sell" the railroad men electro-pneumatic control and especially those applications involving that control with two engines on one car. At least those railroad men who have had some actual experience with gasoline rail-cars will be skeptical.

Well designed clutch-change-gear-propeller-shaft systems have given good results in service. The three Mack cars on the New Haven have jointly run nearly 250,000 miles and have had very little attention paid to their transmission systems.

Generous bearing surfaces and strength of parts should prevail because dependability is of first importance and the small additional weight necessary is well placed. Low angularity on propeller-shafts is very important and is another reason favoring placing the engines of change-gear cars under a hood rather than in the car body. The relation to the front truck and the car body as regards overhang is a third reason.

Recent developments of the gas-electric proposition are interesting and very promising of success, especially where car size, weight and power make gear-shifting difficult or where double-end or multiple-unit control is desirable. However, at present a 60-passenger car with remote control either through electric or hydraulic transmission costs from $10,000 to $12,000 more than a change-gear-propeller-shaft car of the same capacity. Also, it costs more to operate because of the lower transmission-efficiency and the greater weight. The weight

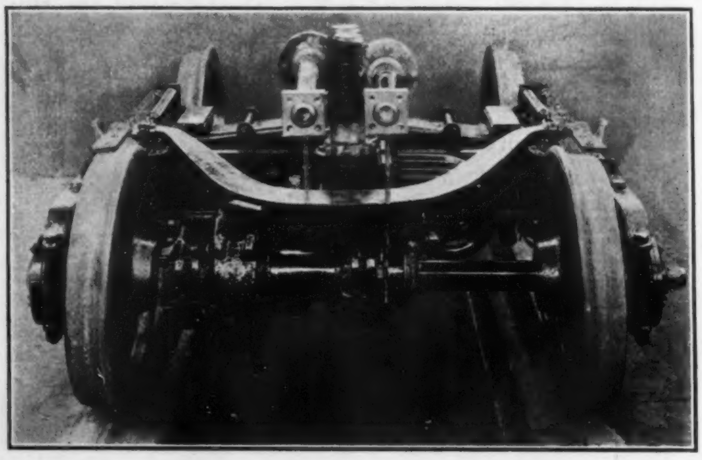


FIG. 3—END VIEW OF THE TRUCK
This View Was Taken at Right Angles to That Reproduced in Fig 2 and Shows the Truck Head On

is approximately from 10 to 20 per cent greater than with a change-gear car; hence remote control exacts a heavy premium per unit of car capacity. Therefore, where costs are of first consideration, the change-gear type is likely to hold the field for some time to come.

THE NEW HAVEN HYDRAULIC CAR

When, two years ago, the New Haven railroad needed a remote-controlled 60-passenger car and the gas-electric type was not at its present favorable stage of development, recourse was had to the hydraulic system known as the Waterbury speed-gear, and a car weighing about 52,000 lb. without passengers was built. It has since operated over 10,000 miles, including service during the winter of 1923-1924. The powerplant is a Ricardo six-

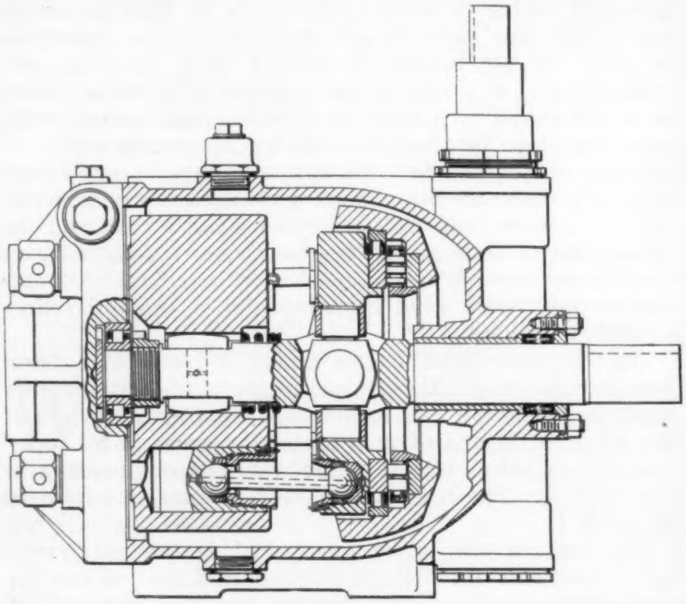


FIG. 4—SECTION THROUGH THE HYDRAULIC MOTOR
These Motors Which Are Geared to the Axles Are Driven by Oil Supplied by the Pump under a Maximum Pressure of 800 Lb. per Sq. In. The Movement of the Trucks Relative to the Car Body Are Taken Care of by Specially Designed Universal Pipe-Joints

cylinder engine of $5\frac{5}{8}$-in. bore and $7\frac{1}{2}$-in. stroke. It is rated at 170 b.hp. at 1200 r.p.m., the operating speed. The Waterbury equipment consists of a 100-hp. hydraulic pump and two 50-hp. hydraulic motors connected through spur gears to one axle of each truck, the latter being loaded eccentrically in ratio 60:40 to increase adhesion. Fig. 1 shows the engine, the 100-hp. pump, the fan and the compressor mounted on a common bed before installation in the car body. Figs. 2 and 3 are side and end views respectively of a truck with the hydraulic motor mounted in place. A section through the hydraulic pump or motor is shown in Fig. 4. Fig. 5 is a side view of the car.

The car is controlled from either end by control boxes connected underneath the car by a shaft carefully supported in roller bearings. The control is accomplished by operating the so-called tilting-box of the hydraulic pump, through which the displacement of the pump plungers is varied between zero and maximum, and which also is reversible. Oil, at pressures up to 800 lb. per sq. in., is driven by the pump to the fixed-displacement motors geared to the axles. Specially designed universal pipe-joints satisfactorily handle the movements of the trucks relative to the car body. The pump is connected by reduction-gears to the engine, which is operated at a governed speed of 1200 r.p.m.

I believe that the hydraulic transmission is the best

yet available of a purely mechanical nature involving remote control for large rail-cars and that for single-car operation it will compete with the gas-electric on the basis of first cost, transmission efficiency and economy of maintenance. Neither the hydraulic system nor the gas-electric permits the same economy of weight and floor space that the change-gear design gives.

Gear-Ratio

Closely related to the brake horsepower of the engine and the car weight are the gear-ratios. Success or failure with a given car and engine may depend upon the gear-ratios. They must be such that the engine is neither overloaded nor overspeeded. They should be such as to permit the engine to develop the desired power at a favorable and therefore moderate engine-speed. They should also be such that reasonably high car-speeds will obtain at moderate engine-speeds.

The lower engine-speeds also mean less vibration and noise, which contributes to the comfort of the passengers. It is a well-known fact that a gasoline engine operates more smoothly at a given high speed when under load than when light. This fact must be kept in mind in

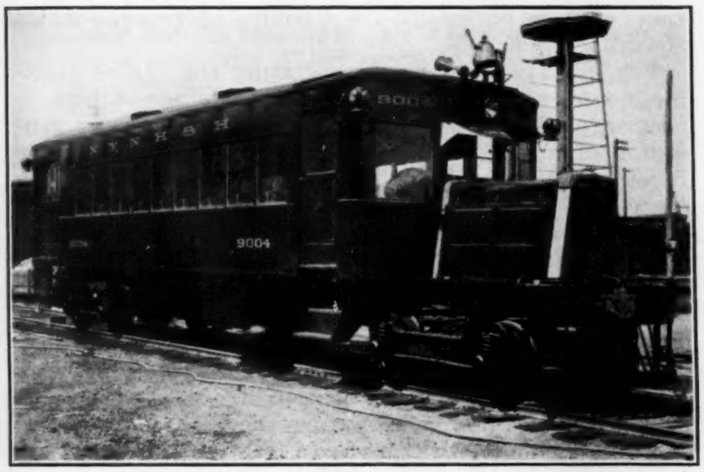


Fig. 5—Side View of the Car Equipped with a Hydraulic Transmission

The Powerplant with Which This Car Is Equipped and Side and End Views of the Power Truck Are Reproduced in Figs. 1, 2 and 3 Respectively

connection with the gear-ratio, for at times the engine will be called upon to furnish only a small amount of power but at a high car-speed, as when the car is descending a long light grade. Under these conditions the engine operating at the lower speeds will give the best-operating car because the vibration and noise will be less. Current designs of gearbox arrangement giving six gear-ratios provide the necessary flexibility with two so-called direct-drives.

Single and Double-End Control

For most railroads, the question of single-end versus double-end control cars is not troublesome. They have Y's, loops or turntables situated conveniently near their terminals. The New Haven, with some terminals in thickly settled centers and with engine houses and turntables so located as to be reached only by movements through extensive yards, is not so well situated. A double-end controlled car that can make a turn in 5 min., where a single-end car would require ½ hr. at least and, in times of unfavorable traffic conditions with respect to making crossovers and the like, incident to getting to the turntable, even longer, is almost a necessity. On

Fig. 6—One of the Early Motor Rail-Cars

This Car Was Placed in Service Early in 1922 on a Schedule Calling for 146 Miles per Day. In the First 5 Months of Its Operation, 533 Trips Having a Total Mileage of 12,441 Miles Were Made, the Total Delay per Trip Being Only 0.4 Min.

one assignment a double-end car had a schedule calling for a 5-min. turn at each end of a 1-hr. run. The car could be made ready while the baggage and the passengers were discharging, as it was only necessary to change control-handles and markers. From the operating man's standpoint a double-end car is unquestionably more flexible and desirable and capable of greater use than a single-end car.

Multiple-Unit Operation

Closely associated with double-end control is multiple-unit control and operation. By multiple-unit operation is meant the running of several cars together in a train by one engineer, with either end of any of the cars equipped with control apparatus or capable of being so equipped and run at the head end of the train. For multiple-unit operation either the electric-generator-electric-motor combination or the mechanical-gear-electro-pneumatic control must be used. Trailer operation with a single-end operated motor-car is of course fairly common, but the tendency is to run the trailer most of the time under conditions where one large eight-wheel car would be better.

Car Performance

To have a unit car take satisfactorily with the operating department and the public, it must have good speed-characteristics. A reasonably fast car should have a balancing speed of between 45 and 50 m.p.h. on level tangent track and of approximately 25 m.p.h. on grades up to 2 per cent. On certain small roads the passengers carried are not so exacting regarding fast operation as those nearer the larger cities; accordingly, the above specifications should be modified considerably. On systems where unit cars must use portions of the main line in their trips and also make connections with through-trains they must have a speed high enough to keep their place without holding-up traffic. The maxi-

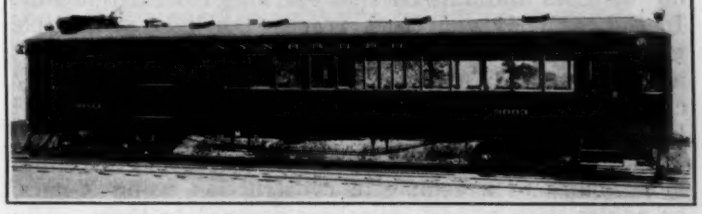


Fig. 7—A Double-End Motor Rail-Car Seating 55 Passengers

This Car Seats Two Passengers on One Side and Three on the Other. Such an Arrangement Provides the Greatest Possible Number of Seats per Pound of Material

mum speed must be considered with respect to car size, weight and construction, so that comfort of the passengers, safety and good riding-qualities shall be assured.

Distribution of Car Space

The total available floor-space of a gasoline car may be divided into five parts, namely:

(1) Engine room
(2) Baggage room
(3) Smoking section
(4) General passenger-section
(5) Platform

After considerable study of various floor-plans the New Haven railroad concluded that for a small single-end car the arrangement represented by cars 9000, 9001 and 9002 (see Figs. 5 and 6) was by far the best. For a large double-end car the arrangement represented by car 9003 (see Fig. 7) is the best. To obtain the greatest possible number of seats per pound of material, a seating arrangement of two on one side and three on the other side has been adopted. In the gasoline cars in operation to date for nearly 3 years this has proved satisfactory; in fact, so satisfactory that the New Haven has converted a number of its main-line coaches in commuter service, and expects to convert more, to the three and two arrangement. A single passenger in a seat arranged for two is comfortable, as are two passengers in a seat arranged for three. On this basis the car must be three-fifths full or loaded to 60 per cent of its capacity before any passenger has only his alloted space. New Haven gasoline cars operate at such a good load-factor for only a small percentage of their time. Special attention was given to obtain a light-weight seat that would be strong and ample in room. The cushions are 15 in. wide and spaced on 28½-in. centers. The seats holding two passengers are 33 in. wide and those holding three are 51 in. wide.

In small cars using an engine of 64 b.hp. and seating approximately 35 passengers, a baggage-room 6 ft. long is about as large as it is possible to provide. In cars using a 150 b.hp. engine and seating 40 or 45 passengers, a baggage-room 8 or 9 ft. long can be used. In the largest cars, using 225 or 250-b.hp. engines, a baggage-room from 12 ft. to 16 ft. long may be used. Folding benches located in a baggage-room can accommodate passengers when baggage is not being carried. In large cars for use on long trips a smoking compartment is desirable as it satisfies some passengers and leaves no room for complaint regarding the curtailment of facilities.

General Design

The car wheelbase should be made as long as possible, and the overhang of the body at both ends of the car should be kept as short as possible. A car with a long wheelbase rides better and operates the highway-crossing electric-signals better. All wheels should be pressed on the axles and anti-friction bearings mounted outside. In the car body and truck frames the lightest possible material and sections that are consistent with strength and ease of maintenance should be used. In many cases this means the use of alloy-steels or other special high-quality material. Cars built for the New York, New Haven & Hartford Railroad to date, or building, have bodies of a composite construction using T-bars, or angles with wooden members secured to them. The floors and the sides have been insulated to help keep the car warm. Outside sheathing and other steel plates should be copper-bearing steel having a copper-content of about ¼ per cent. The life of these plates is double that of the ordinary plate and their first cost is but little more.

A good type of ventilator should be used in passenger, baggage and engine-rooms. In cases where the engine is enclosed in the body, special care should be taken to assure ample ventilation in the engine-room.

In cars operating in cold climates adequate provision must be made for heating by some means other than the engine exhaust, otherwise, unless the engine is working hard at all times, the car will be cold. A coal-heater with a hot-blast air-fan distributing the heated air through a duct along one side of the car at the truss plank is satisfactory, and has received the approval of the Public Utilities Commission in several States.

The question of providing a dry hopper or not is one that can be settled only by the service requirements. If possible, it should be omitted.

Coat-hooks and basket-racks keep the aisles and seats clear and promote comfort and speed of loading and unloading. Advertising-racks located under the basket-racks and on bulkheads are a source of revenue which should be used.

For lighting the car and operating the engine starting-motor, a large and substantial storage-battery is necessary. To keep the battery properly charged a generator of adequate size must be used to meet winter requirements when lights are used for a long time while the car is standing and when the duty of starting the engine is high. Generators range in size from 250 watts on the small cars to 1 kw. and over on the large cars. The smaller generators can be mounted directly on the engine, but the larger ones require a special drive. While 6-volt generators and miniature lamps are used on small cars, the large cars should have 32-volt generators and standard screwbase sockets, both of these being standard in railroad practice. The wiring should be done in an approved manner with approved switches, fuse-blocks, junction-boxes and similar fittings.

For safety and to make good schedule-speeds, air-brakes are necessary even on the small cars. Diaphragm airbrake systems have not proved adequate or satisfactory. The best brake-system is one using a foundation brake-rigging similar to that used on standard railroad-cars, but of smaller size, supplied with air from small mechanically-driven compressors.

The principal purpose in using gasoline rail-cars instead of steam trains is to provide service to the public at less cost to the carrier. Three Mack cars that have been in service on the New Haven since January, 1922, having a credit of 217,000 miles to July 31, 1924, show that the cost per mile is approximately as given in Table 2.

TABLE 2—OPERATING COST PER MILE OF A SIX-WHEEL GASOLINE RAIL-CAR

Fuel	$0.045
Lubricant	0.007
Maintenance and Overhaul	0.120
Other Supplies	0.006
Garage	0.024
Sub-total	$0.202
Train-Crew's Wages	0.170
Total	$0.372

The Operation and Maintenance of the Motorbus

By J. B. STEWART, JR.[1]

AUTOMOTIVE TRANSPORTATION MEETING PAPER *Illustrated with* DRAWING

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ABSTRACT

AMERICAN cities depend upon transportation for their development, the kind of transportation depending on the size of the community. Motorbuses alone could not handle the traffic of New York City; subways and elevated railroads are not needed in cities having less than 200,000 population. Each city must solve its own separate and distinct problem. It is doubtful whether motorbuses ever will supplant an existing rail-line that serves an industrial section in a city of more than 150,000 people. This question was debated recently in a certain city where it was considered advisable to replace a bridge on the line of the railway rather than incur the expense of purchasing motorbuses.

The motorbus has a definite place in every city. In large cities it can be used for limited-load service; in medium-size cities, as a feeder to existing rail-lines from undeveloped territory; in small cities, to replace railways that have become obsolete or would require large sums of money to be put into condition to operate efficiently and economically. In medium-size cities also, motorbuses are used when the cost of replacing track and paving would necessitate too great an expenditure of money. In Newburgh, N. Y., the entire transportation of the city is rendered by 22 motorbuses, which serve 30,000 people.

Inter-city operation has passed the experimental stage and is to be found in all parts of the Country, the routes varying in length from that of short suburban lines to 300 to 400 miles, as is the case in California. In urban operation persons usually prefer to pay a higher rate of fare to ride on rubber; the difficulty of obtaining suitable parking-space also influences owners of private automobiles to use their cars for pleasure riding and to rely on the regular service rendered by motorbuses and rail-cars in going to and from their places of business.

When competing with a rail-line an entirely new class of traffic seems to develop. In one locality the traffic over a motorbus system paralleling a rail-line required that the service be increased from hourly to 15-min. intervals, but the earnings of the rail-line were not appreciably affected.

Before the railway equipment companies will submit quotations on equipment for railway lines they demand full information regarding the details of the service to be rendered. If this is not forthcoming no quotations can be obtained. Comparatively little study has been given to this matter by motorbus companies and much equipment has been installed that is unsuitable for the service that is expected to be performed.

But some operators are unreasonable in their demands. It is practically impossible to build a chassis that will carry a 25-passenger motorbus with a capacity load at a speed of from 30 to 45 m.p.h. and still be able to pull the same load up a 5-per cent grade a mile long in high-gear. This would require either a very large engine or too high a gear-ratio.

The study of brake-rigging is important, for the large number of stops imposes severe strains on the braking system. Lighting conditions vary with the service, and equipment for this purpose should have careful attention. Maintenance is given too little consideration, it being necessary frequently to remove many other parts to get at the part to be repaired or replaced. Relining the rear-wheel brake-bands is a difficult task, necessitating the removal of the wheel to get at the brake-band. This operation should be simplified. The tire problem has been satisfactorily solved through the medium of tire mileage contracts in which the charge for tire service is made on the basis of the number of miles traveled multiplied by the rate per bus-mile that has been agreed on.

Difficulty regarding the application of chains in wet weather has been lessened by the use of reinforced cross-link chains In the winter time 34x5-in. tires are used but, because of the greater mileage that can be obtained, 36x6-in. tires are preferable in summer.

Railway men prefer to make repairs over a pit. In the case of a motorbus, however, this has several disadvantages that are peculiar to the motorbus. Among these are the danger due to poisonous gases that are given off by the engine and sink to the bottom of the pit, and the water that is always to be found about a garage on account of washing, rain in the summer time and melting snow and ice in the winter. Even though adequately drained the pits are always left wet. These difficulties are overcome by lifting the motorbus above the floor by an incline leading to a skeleton track, by raising the motorbus by jack-screws placed underneath the corners or by hoisting the motor bus to a concrete pier by a chain-hoist.

Ventilation must be provided to remove foul air from inside the motorbus during the cold weather and at the same time keep out rain. For heating, a system similar to that used on steam-railroad passenger-coaches has proved satisfactory.

The standard commercial-vehicle chassis formerly used for motorbuses have given way to special designs; the future development of the industry will depend largely upon the men whose duty it is to design and build the chassis and the body.

AFTER I had written the thoughts that came to my mind and had read over the story as outlined in this paper, I came to the conclusion that this subject might better have been Lessons Learned Through Experience in the Operation of the Motorbus. The conclusions that have been reached are the result of motorbus operation on the property with which I am connected, interurban coach operation having begun in August, 1922, and city operation having commenced on Sept. 24, 1922. Since that time the number of motorbuses has increased from 7 to 42. Up to July 31, 1924, the motorbuses have covered a total of 1,887,823.55 bus-miles and have carried 8,604,867 passengers.

[1] General superintendent, Youngstown Municipal Railway, Youngstown, Ohio.

There seems to be little question in anyone's mind that the growth of the American city is dependent on its transportation system, whether it be private automobile, motorbus, electric rail-car, subway or elevated, or the suburban steam train, the means of transportation depending in a large measure on the size of the community. No one would think of attempting to handle the transportation of a city as large as New York City, Boston or Chicago with motorbuses or surface cars alone. On the other hand, subway or elevated transportation is not required in cities of 200,000 population. Outside these general conditions, however, the transportation requirements of each city is a separate and distinct problem depending on the size of the city, the location of the large industries and the business district with regard to the residential section, the number and direction of the main arteries of travel, and the types of the industries.

Personally, I do not believe that the motorbus can ever supplant an existing surface rail-car line that must serve an industrial section in a city of more than 150,000 population. In a certain city recently, a transportation company was faced with an estimated expenditure of $150,000 to replace a bridge over which cars serving an industrial district were operated. Several other bridges were in the vicinity of the structure that had to be replaced but, owing to certain conditions, it was considered inadvisable to lay rails over these bridges. A study was made of the possibility of using motorbuses to replace the existing rail-lines, the service on which consisted of 6 cars in the non-rush and 15 cars during the rush period. It developed that 30 motorbuses would be required to handle the rush-hour traffic which, with a reserve of 1 motorbus in 5 as a spare, would mean the purchase of 36 motorbuses at an expenditure of approximately $250,000. As the remainder of the track structure on the particular lines served by this bridge was in reasonably good condition, it was decided to replace the bridge.

The Motorbus a Permanent Fixture

The motorbus has a very definite place in every city, regardless of size. It can be used to furnish limited-load service in large cities at a higher rate of fare than that charged by rail-lines, as is now being done in New York City, Detroit, Chicago and St. Louis. A great number of persons can afford and are willing to pay a higher rate of fare for the special service rendered. In a medium-size city, the motorbus can be used as a feeder to the existing rail-lines, the motorbus routes extending into newly developed territory that does not have a sufficient number of residents to warrant a rail extension. The experience with such motorbus routes will serve as an index of the patronage that can be expected from the district served and, when the patronage warrants, the rail-lines can be extended and the motorbuses moved to later real-estate developments. A field for motorbus operation also exists in medium-size cities where the track structure of existing rail-lines serving residential districts must be replaced and the cost of replacement together with the usual incidental paving requirement is so great that the earnings would not justify the expenditure. In some cases it has been found desirable to remove the track and overhead construction at the time that the municipality repairs the street and to substitute motorbus service for rail-car service.

In many of the smaller cities having populations of from 25,000 to 50,000, the existing track and overhead structure, as well as the power-producing or converting facilities and the rolling stock, has become obsolete and, if the property is to continue to transport passengers, a considerable expenditure of money would be required to place the property in condition to operate efficiently and economically so that passengers might be carried at a reasonable rate of fare and the owners receive a reasonable return on their investment. In cities of the size mentioned, it is imperative that the rate of fare be kept low; otherwise the people will walk from their homes to their places of business, or vice versa, which can be done in a very short length of time. A good example of the substitution of motorbuses for rail-cars is that of Newburgh, N. Y., a city of some 30,000 people, where 22 motorbuses have been giving all the transportation service for 22 months.

Use in Inter-City Service

The use of the motorbus in inter-city service has long since passed the experimental stage. We find inter-city operations from Maine to California and from Canada to Mexico; in fact, I recently inspected an inter-city motorcoach that was one of an order being shipped to Brazil. These inter-city routes vary in length from the short suburban runs of from 10 to 15 miles to the long inter-city runs, such as those in California, of from 300 to 400 miles. In inter-city as well as in city operation, local conditions must govern as to whether a route will prove profitable. Again, as in urban operation, it has been found that persons are willing to pay a premium in the form of a higher rate of fare to ride on rubber. A further interesting result of motorbus operation has been the use of both urban and interurban motorbuses and motorcoaches by the owners of private automobiles. The difficulty of obtaining parking-space in the business district and the restriction in the length of time that an automobile may be parked have influenced a great many automobile owners to use their cars for pleasure riding only and to rely on the regular scheduled service furnished by rail-cars and motorbuses of an established transportation agency in going to and from their places of business.

A rather interesting sidelight on the class of passengers on inter-city coaches is furnished by the experience of a company that established inter-city coach-operation about 2 years ago between two cities already connected by an interurban rail-line, on a highway directly adjacent to the rail-line. This motorcoach line, which originally operated on an hourly headway, is now operated on a 15-min. headway during the greater part of the day. The remarkable thing about this operation is that the earnings of the rail-line have been affected but little, if any, by the motorcoach operation; from which we conclude that the passengers using the motorcoaches are persons who formerly did not use the rail-cars and used either the steam line between the two cities or their own cars.

It seems to be pretty generally conceded that the motorbus and the motorcoach are to be permanent and that they should be operated by the existing transportation agency, under regulation, in order that the responsibility for service and for the rate of fare may be placed with one responsible agency rather than be distributed among a large number of individual motorbus owners.

Selection of the Motorbus or Motorcoach

In the electric-railway business, whenever a company desires to purchase new cars, or new equipment, such as motors, controllers or air-compressors for new cars, or to replace similar equipment on existing cars, it sends

out an inquiry for quotations to the several manufacturers furnishing such equipment, who, before quoting, will send either a technical representative or a data sheet to the prospective purchaser for the purpose of securing certain data. The information requested is with regard to the length of the run, the schedule speed, the lay-over time at each end of the run, the number of stops per mile and per trip, the curves and the grades. It is practically impossible for a purchaser to secure any equipment unless he has furnished this information, the manufacturers taking the position that unless they know the kind of service in which the equipment is to be operated, and unless the equipment has been designed to operate under these conditions, it is not fair to ask them to guarantee the equipment and make good any failures. Personally, I think their position is well taken.

My experience with the automotive industry has been that the entire effort thus far expended has been concentrated on the actual sale by salesmen, and that little or no effort has been put forth to study the conditions under which the motorbus is to operate. I have heard of motorbuses being sold for use in inter-city service in which a speed of 30 m.p.h. had to be maintained for several hours, with a rear-axle ratio of 7.5 to 1.0. To anyone who has given the subject consideration, it will readily be seen that an engine would not long survive under the vibration that would be set-up at the engine speed necessary to operate the motorbus.

On the other hand, I believe that many operators are unreasonable in their demands. Last year, I had a long discussion of the subject of motorbus design with a gentleman who, I believe, has had greater experience with and knows more about motorbus design and operation than any other man in this Country. He took the position that it was impossible for a chassis manufacturer to design and build a chassis that would be economical to operate, easy to maintain and have a reasonable length of life and at the same time comply with the requirements of some purchasers. It is practically impossible to build a chassis that will carry a 25-passenger-motorbus with a capacity load at a speed of from 30 to 45 m.p.h. and still be able to pull the same load up a 5-per cent grade a mile long in high-gear. If the engine were large enough to handle the motorbus under such conditions, it would be extremely heavy and probably would not be economical in the consumption of gasoline. If the rear-axle ratio were high enough to allow a normal-size engine to comply with the grade requirement, it would cause the engine to operate at an excessive speed on the level. Our experience seems to indicate that the best results can be obtained by using a rear-axle ratio that will allow the engine to operate in high-gear at its most efficient and economical speed for the greater part of the route and drop back into a lower gear when it is necessary to traverse the small portion of the route located on grades. One route that I have in mind is 15 miles long. About ½ mile of this distance is represented by grades of from 3 to 4 per cent, located at two different places. The motorcoaches operating on this route are equipped with a 4¼ to 1 rear axle, and it is sometimes necessary for the driver to drop back into third-gear on the hills; but for the greater part of the trip the engine operates at a comparatively low speed, thereby securing low gasoline-consumption and reducing the wear and tear on the engine.

Study of Brake-Rigging

A prospective purchaser should give considerable study to the design of the brake-rigging on the motorbus chassis that he is about to purchase. With one or two possible exceptions, the motorbus-chassis manufacturers have not come to a realization of the work that is required of the braking system. Although we were having trouble with the brakes on a certain make of chassis, the manufacturer could not understand why we should be so troubled, as its commercial cars had always given entire satisfaction in this respect. An engineer was sent to investigate. The particular line on which this motorbus was operating was about 2 miles long, the schedule requiring that it be traversed in 20 min. It was found that the motorbus was averaging 15 stops each way, or 7.5 stops per mile, some of which were made on a 2-per cent descending grade. After this investigation, this particular company redesigned the brake-rigging, and no further trouble has been experienced. The varying load-conditions experienced in motorbus operation must also be kept in mind by the designer of brake-rigging to the end that as the load is added, the brakes will not tighten or loosen, as the case may be, because of the eccentric action of the brake pull-rods around the rear axle as the chassis frame rises or lowers under varying conditions of load.

One of the greatest advertisements and "passenger-getters" in motorbus operation, in my opinion, is a well-lighted motorbus. The General Electric Co. has made a very complete study of lighting conditions in motorbuses and is ready to make studies and recommendations at any time that a request may be made. The design of the socket and the lamp, however, and the selection of the proper type of reflector to give the best distribution of "foot-candles" to secure the best illumination and to avoid shadows, are a very small part of the problem. It is a simple thing to say that the body-lamps should consist of six or eight 32-cp. lamps, but when we come to the point of providing energy to light the lamps we are facing a serious problem that divides itself into two separate and distinct propositions, that is, interurban and city service.

It is my personal opinion that the battery should not carry any of the lighting load except for comparatively short periods of time when the engine happens to be shut-down. The sole function of the battery, therefore, is to carry the lights during these periods and to furnish current for the starting-motor. In interurban service, the problem is comparatively simple and resolves itself into the designing of a generator of sufficient capacity to carry the lighting load. The speed of the interurban motorcoach is usually high enough to drive the generator at a speed that will cause it to produce its rated output. In city service, with the numerous stops and slow-downs, it is rarely possible for the engine to operate for any length of time at a speed that will permit the generator to produce its rated output. It, therefore, becomes necessary either to introduce step-up gears or to design an armature that will produce the rated output at a lower engine-speed. In several instances the first scheme has been followed, but with some engines it is impossible to make the gear installation; the generator manufacturer is then compelled to design a low-speed armature. The introduction of the low-speed high-charging-rate armature introduced another complication in the form of battery trouble, owing to the buckling of the plates because of the high charging-rate. This has been overcome through the use of voltage regulators and other similar devices. When our fleet consisted of some 32 motorbuses equipped with the standard type of generator, the battery-charging bill averaged $150 per month. With 42 motorbuses now in operation, practically all of

which have late-type generators, the battery bill has been reduced to $25 per month, which includes all the repairs as well as charging.

Repairs and Replacements

First-class parts carefully inspected and assembled should, theoretically, make a perfect motorbus chassis that, if properly inspected and lubricated while in service, should operate indefinitely. Unfortunately for the motorbus operator, this stage of perfection, in either the manufacture or the operation of motorbuses, has not been reached, and repairs and replacements must be made at frequent intervals. When these occasions arise, the maintenance foreman and his mechanics find that they lose much time on account of having to remove many other parts to get at the part to be repaired or replaced. In other words, the manufacturer has not yet given enough thought to the maintenance of the chassis after it gets into service. Our experience with many different makes of motorbus chassis has been that, although the parts may be well made and carefully assembled, they are assembled, so it seems to the operator, with the idea in mind that, once they are combined into a complete chassis, they will not have to be removed until the life of the chassis has ended and the chassis finds its way to the junk-yard. Cannot the designers help the operator by giving this subject their careful thought, to the end that, if a clutch goes bad, he can get it out in the minimum length of time and without having to take the transmission apart to get at the clutch?

Another maintenance problem comes to mind, that is, the problem of relining rear-wheel brake-bands. At present, it is a rather extended task necessitating the removal of the wheel to get at the brake-band. It has always seemed to me that some scheme could be worked out for the rear-wheel brakes similar to that of the propeller-shaft brake-shoes, so that the shoes having worn-out linings could be removed and a new set installed without removing the wheels.

The tire problem has been solved by some operators, of which the company with which I am connected is one, through the medium of tire-mileage contracts. Under this plan, the operator does not own, service or repair any of the tires used on his motorbuses. The operator's duty consists only of keeping an accurate record of the miles operated by each motorbus and making a report to the tire company at the end of each month. The number of miles multiplied by the rate per bus-mile that has been agreed upon constitutes the charge for tire service.

Offhand, it would seem that the operator would have no incentive to take steps to prevent the misuse of tires or to endeavor to secure high mileage. Such an attitude upon the part of the operator would be very shortsighted, for his next year's rate would undoubtedly depend largely on the previous year's record.

Speaking after an experience of more than 2 years of motorbus and motorcoach operation, we have no cause to complain of the treatment that we have received from our tire contractor. It has never been necessary for us to suggest to him that the tread was too far gone to allow good traction or that a blow-out was imminent on account of the weakened condition of the tire. These conditions have all been taken care of by the contractor in a very satisfactory manner and it is our opinion that the method described is the only really satisfactory way in which to handle the perplexing problem of tire-service adjustments.

Use of Anti-Skid Devices

Traction on pavements made slippery by rain, snow or ice presents a problem that has yet to be solved. Little or no difficulty is experienced on wet pavements by motorbuses equipped with dual rear tires, but a very small amount of snow will make the pavements so treacherous that no operator would care to risk the lives and limbs of his patrons by operating without some aid to traction.

From your experience with passenger cars, you will probably agree that an ordinary set of chains will last from 200 to 300 miles before the cross-links begin to break. A so-called de luxe type of chain will probably wear half as long again. When we stop to consider that a motorbus in regular service travels approximately 225 miles per day and averages 7.5 stops per mile, it will be apparent that the ordinary type of chain will last hardly through 1 day. In our operation we have found that the so-called "dual" chain, that is, a chain having a ring chain both inside and outside the inner dual wheel, with cross-links across both tires, is out of the question because of the bumps transmitted to the passengers and also because the damage done when one of these heavy cross-links breaks. Single 36x6-in. chains were next experimented with, but the short life of the cross-links made it necessary to change the chains frequently. With this size of tire and chain, it was found to be impossible either to apply or to remove the chains without loosening all the nuts holding the wheels in place, and allowing the wheels to drop apart. This, of course, meant jacking up the motorbus, which consumed time in our case averaging from 20 to 30 min., and meant that it was impossible to apply chains to motorbuses without taking them out of service. During the rush-hour period this would be a serious matter.

Reinforced Cross-Links

As a result of this conclusion and because of the short life of the standard cross-link, we began an investigation to discover some means of remedying this condition. For the longer life of the cross-links, we naturally turned to the newly-developed reinforced cross-link but found that it was not made larger than 5 in. in size, so, as an experiment more than anything else, one motorbus was equipped with 34x5-in. tires. It was found that the single 34x5-in. de luxe chain could be applied to this tire without removing or even loosening the wheel; in fact, all that it is necessary to do is to spread the chain out on the pavement, run the wheels onto the chain and fasten the catches, the entire transaction not consuming more than from 3 to 5 min. It was found that the life of the reinforced cross-link was from three to five times that of the standard type. The 34x5-in. tire endured very well during the winter months, even though severely overloaded, but during the summer months it would not give the mileage, so that the present practice is to use 34x5-in. tires during the winter months and change to 36x6-in. tires during the summer. This is but one way of getting out of a difficulty. We believe that the subject of chains and their application should be given additional study by the manufacturer of the chassis, wheels and chains to the end that the operator may be able to apply chains when it is necessary in the least possible time, without seriously delaying a motorbus or taking it out of service, and that the chains will give the longest possible life.

Officials of electric-railway companies, who are now charged with the maintenance of motorbuses, cannot become reconciled to the practice of a mechanic's attempting to make repairs on a chassis while lying on his back.

As perhaps a great many of you are aware, it has long been the practice in street-railway repair shops to have pits of sufficient depth to allow a man to stand erect while making repairs. It seems to me that without question a man is able to use his strength to better advantage while working in a pit, on account of the greater space available. Such a result can be obtained in several ways. The first, of course, is the use of the pit. The pit has several draw-backs that are peculiar to motorbus operation and are not encountered in street-car maintenance. The most serious of these is the poisonous gases given off by the engine. These gases, being heavier than air, naturally sink to the bottom of the pit and, unless means are provided for carrying them away, are likely to cause illness and possibly death to persons working in the pit. A certain amount of water is always to be found about a garage on account of washing the garage floor, water dropping off motorbuses after they have been out in the rain and, in the winter time, the melting of snow and ice carried in on the motorbuses. A greater or less quantity of water is likely to find its way into the pit, and adequate drainage facilities must be provided, which, even at the best, will serve simply to carry off the water, leaving the pit wet.

Overcoming the Disadvantages of the Pit

If pits are not entirely satisfactory, the only other way to secure room under a motorbus is to elevate it a sufficient height above the floor; this plan has been adopted in several instances and has been accomplished in several ways, the simplest of which is that of having an incline leading up to the skeleton track that is elevated about 4 ft. from the floor, very much like the grease and oil-changing racks that are now becoming so common at filling-stations throughout the Country. The principal objection to this scheme is the amount of room that it requires in the usually already crowded garage. A very satisfactory but rather expensive method, so far as first cost is concerned, is by a device built by one of the railway-equipment companies. This consists of two channel-sections properly reinforced, and assembled so that they give proper gage for the motorbuses, being normally flush with the surface of the floor. At each corner are a jack-screw and the necessary guiding devices. The jack-screws are all operated through gear-trains by one motor so that the motorbus can be raised or lowered with the track supports on a horizontal plane.

A rather inexpensive but at the same time efficient device has been worked out by the mechanical department of the company with which I am connected. This device, which is shown in Fig. 1, consists of a concrete pier about 4 ft. high and 8 ft. long. While the pier was being built provision was made for connecting to the pier two channel-sections that were to serve as tracks for the motorbuses. At the opposite end of the channels, which normally rest on two short concrete ramp sections, two 2-ton chain-hoists were attached, which furnish the means of lifting the rear end of the motorbus to a level with the front end. The web of the channel at the permanently raised end of the device was bent to correspond to the circumference of the wheel, thereby forming a stop. Blocks having the same contour are provided for the rear end, provision being made to bolt them to the channel. After the motorbus has been lifted to its proper position, heavy blocks are placed under the channels as a safety precaution, but the load is still left on the chain-hoists. The entire cost of this device does not exceed $400 and it is operating with a very great degree of satisfaction.

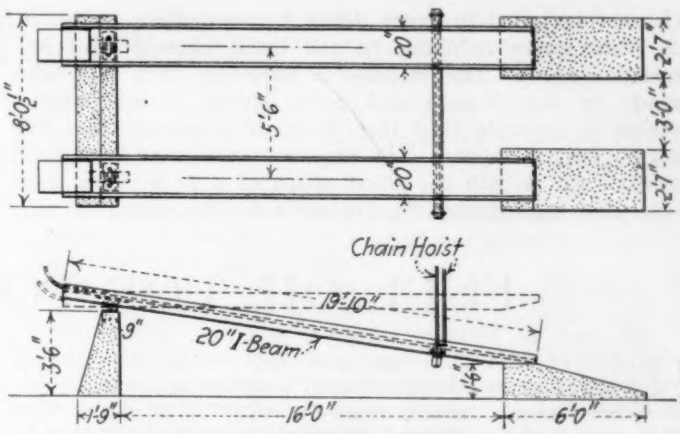


Fig. 1—Motorbus Elevating Work Rack

This Device Was Worked Out by the Mechanical Department of the Youngstown Municipal Railway as a Substitute for an Incline Leading up to a Skeleton Track That Is Elevated about 4 Ft. above the Floor, an Arrangement That Takes Up Considerable Room in an Already Crowded Garage. It Consists of a Concrete Pier about 4 Ft. High and 8 Ft. Long and Having Two Channel Sections Connected to It Which Serve as Tracks for the Bus. The Opposite End of These Channels Rests on Two Short Concrete Ramp Sections and Two 2-Ton Chain Hoists Provide Means for Lifting the Rear End of the Bus to a Level with the Front End, Thus Providing Space for the Workmen To Get Underneath the Vehicle. The Web of the Channel at the Permanently Raised End Is Bent To Conform with the Circumference of the Bus Wheel and Forms a Stop

Ventilation

Motorbuses are operated from 20 to 24 hr. each day, 365 days a year, through all temperatures and weather conditions. It is a comparatively simple matter to provide ventilation during the summer months when no one objects to having all the windows and the windshield open; but during the fall, winter and spring, when it is too cool for the windows to be open, ventilation must be provided by ventilators. There does not seem to be much need of ventilators for providing fresh air, as there is enough leakage around the body of the motorbus to take care of this, but they must carry off the foul air and at the same time keep out the rain.

The heating of motorbuses, although very much improved over the first attempts, still deserves very careful study. The first motorbuses that we received depended for heating entirely on two small patented-type heaters, located on either side of the motorbus under the first cross-seats. No attempt might just as well have been made to heat the motorbus, particularly insofar as the driver was concerned, for what little heat was given off was driven to the rear of the motorbus. The next experiment in heating was by thin-wall piping running around three sides of the motorbus and covered with a perforated-metal shield. So far as heating the motorbus was concerned, this method proved to be satisfactory, but the location of the pipe was undesirable. The next, and to date final, arrangement is to locate the pipe close to the side of the motorbus, protected in much the same manner as are the steam-heating pipes in a steam-railroad passenger-coach. So far, this scheme has proved satisfactory in every way.

In conclusion, I wish to give credit to the motorbus builders who, in the comparatively short time since motorbuses have become a definite factor in the transportation industry, have radically changed the design of their product. When motorbuses were first used many persons thought that all that it was necessary to do was to take a standard commercial-vehicle chassis and build a body on it. It was soon found that the traveling public did not care for this kind of transportation. Builders, in many instances, have laid away entirely their commercial-chassis designs and are now placing on the market

chassis designed in every detail for motorbus operation, in some cases refusing to sell these chassis for commercial work. The wonderful progress that has been made in the chassis and body design of motorbuses seems to indicate that this form of transportation has a very bright future. The improvements that have been worked out within the short space of 2 or 3 years indicate that manufacturers are alive to the situation and wish to create a product that will meet all the demands placed upon it. I do not hesitate to predict that, within the next year or two, the slight difficulties that some operators are now experiencing with the chassis as at present designed will be entirely eliminated. The motorbus has a place in the transportation industry and its future will depend largely on the men whose duty it is to design and build the chassis and the body.

FUEL OIL FOR POWER GENERATION

QUANTITATIVELY, gas and fuel oil is the leading product of petroleum refining, constituting about 50 per cent of the total, or nearly twice the output of gasoline. Gas oil is used in the making of illuminating gas and for enriching gas manufactured from coal. In some cases the entire residue after the gasoline and kerosene have been removed is used as fuel oil, and to a limited extent crude petroleum is burned just as it comes from the wells. Not only is this practice wasteful of the gasoline and kerosene, but the presence of gasoline is usually undesirable in a fuel oil.

Increased cruising radius is an advantage enjoyed by oil-burning vessels. Starting with equal tonnages of fuel, the oil burner can make a voyage 50 per cent longer than can the coal burner. The number of oil-bunkering stations throughout the world is increasing, but oil is not yet so widely available as coal for bunkering. Through economical use of fuel by the Diesel and similar engines the motor vessel reduces the cost of operation and gains a greater cruising radius than that of any other type of power vessel. During the recent period of depression in shipping, motor vessels experienced less loss than vessels of other classes as their lower cost of operation enabled them to earn a profit even when freights were low. Their efficiency is established; they have been selected even for such heavy duty as ice breaking in the Baltic, and round-the-world voyages by motor vessels are no longer a novelty.

The world's gross shipping tonnage, exclusive of sailing vessels, now totals some 61,000,000 tons, divided in the proportion of three-fourths using coal only and one-fourth equipped for oil alone or both oil and coal. The strength of the trend toward oil fuel is better shown by recent construction figures. New tonnage built in 1919-1920 was divided almost equally between coal-burning vessels and those using oil alone or both fuels; in the new tonnage of 1921-1922 vessels fitted to use oil, either under boilers or in engines, predominated by almost two to one.

The United States leads the world in oil-burning merchant tonnage. As the greater part of the American merchant marine was built since 1917, modern types of equipment could be adopted. Considering only vessels of 1000 gross tons or over, the tonnage of oil-burning vessels is more than twice as great as that of coal burners. Total world tonnage of steamers burning oil was over 13,800,000 gross tons on June 30, 1922, and of this 8,710,000 gross tons was American. Consumption of fuel oil by Shipping Board vessels amounted to 17,000,000 bbl. in 1921. The United States Navy uses around 7,000,000 bbl. a year.

In the tonnage of motorships the situation is reversed, as the United States holds only 146,000 gross tons out of a world total of 1,166,000 tons. Not only is British tonnage of motor vessels more than twice as great as American, but the size averages much higher. In general, the motorship has made greater advances in European shipping than in American. The records for size will go to a passenger liner of 20,000 tons and freighters of 21,000 tons which are now building in Scotch and German yards, respectively. An important Scandinavian shipping firm recently announced that it would build only motor vessels.

Consumption of fuel oil by locomotives in the United States in 1922 was about 45,000,000 bbl.; in 1921, 41,000,000 bbl., and in 1920, 46,000,000 bbl. These figures are practically complete for all roads using fuel oil. Nine-tenths of the entire consumption is by roads of the Middle Western, Southwestern and Southwestern Pacific States.

A review of refinery production in the United States for a few recent years, covering the four chief products shows that the output of gas and fuel oil and of gasoline has made an unbroken advance while that of the other major products showed a decline in 1922 from high marks reached earlier. Production in millions of barrels of 42 gal. was as follows:

Year	Gas and Fuel Oil	Gasoline	Kerosene	Lubricating Oil
1916	111	49	35	15
1917	155	68	41	18
1918	174	85	43	20
1919	182	94	56	20
1920	211	116	55	25
1921	230	123	46	21
1922	255	148	55	23

So far the supply of fuel oil, although dependent rather upon the production of gasoline than upon the demand for oil, has not limited the extension of its use except insofar as advancing prices have in some fields placed it beyond the level of competition with coal. For those purposes for which it has special advantages, such as marine fuel, its use will probably continue to be extended. In other fields, the use of fuel oil will be determined by the availability and relative cost of coal; here freight and labor charges and the location of deposits will be important factors.—*Commerce Monthly.*

Motor Rail-Cars

By JAMES W. CAIN[1]

AUTOMOTIVE TRANSPORTATION MEETING PAPER

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

REFERRING to the McKeen gasoline-driven car and one of the gasoline-electric type that were introduced in the early part of the present century and were the pioneers among self-propelled cars for railroad use, the author ascribes their limited success to their excessive weight and to engine and transmission troubles. Both these types, he thinks, might have been developed successfully had the gasoline engine been in its present state of efficiency and reliability.

The early attempts having been more or less unsuccessful, the construction of all types was discontinued during the war. More recently the progress in the design and construction of highway motor-trucks has caused them to be adapted to railroad service by applying flanged tires to the rear wheels, pivotal pony-trucks forward and a motorbus body for the carrying of passengers and a limited amount of baggage. These motorbus-type cars weigh approximately 600 lb. per passenger as compared with 1500 lb. in the cars originally used and can be maintained with the same ease and at less expense than can a highway motor-truck. But, although these cars were economical, they were not comfortable to ride in, and they have been superseded by slightly larger cars of light weight equipped with the same automotive-type engine but with two pairs of four-wheel pivotal trucks and swing bolsters. This is the type largely in use at present.

About 3 years ago an investigation of self-propelled cars in this Country and in Europe was made by the American Short Line Railroad Association, 500 questionnaires being sent to members of the association in this Country and in Canada; and many valuable data were acquired regarding the operation of motor cars on short lines and branch lines under all sorts of conditions. The records show that at present 135 roads are operating 164 motor cars, of which 34 are on trunk lines and 130 on short lines. The approximate mileage is 8000. The number of steam trains that have been replaced is 200. One steam road, 108 miles in length, that showed a deficit of $36,000 per year showed a profit of more than $22,000 during the first year of operation with motor cars. The total investment in serviceable rail motor-cars at present is about $2,500,000; the steam-train investment necessary to provide the same service would be from $8,000,000 to $10,000,000.

It is the author's opinion that eventually all branch lines and short lines will become motorized, the limiting factors at present being the inadequate power developed by the most approved type of motor-truck engine. A lower grade of fuel than gasoline will, no doubt, also be found eventually, which will make available a type of internal-combustion locomotive for handling freight service. Increasing the size of the engine will probably require some change in the form of the transmission, for the limit of the present clutch and transmission system has almost been reached. But this may prove to be an advantage.

Among the other economies accruing to the use of the self-propelled vehicle would be the abolition of such facilities as water-stations, coal-stations, round-houses and the like. The cost of maintenance of the road-bed would also be reduced.

With the further development of automotive equipment the complete motorization of short-line and branch-line railroads may be expected to turn the present operating deficits into profits.

Tables are appended showing the operating statement of a motor car for 1 year and an analysis of the operating cost during this period.

BELIEVING that you will be more interested if this subject is treated purely from a practical railroad standpoint, I shall not attempt to inject technical or engineering suggestions or arguments. For many years before undertaking my present work, I had been deeply interested in the solution of self-propelled cars for railroad use and, although some of you may be familiar with their early history, I shall refer briefly to two illustrative types that might have developed successfully and have launched this particular industry on a successful career, had the gasoline engine at that time been in its present state of efficiency and reliability. I refer to the McKeen gasoline car and the gasoline-electric car built by one of the foremost manufacturers of electrical equipment that were introduced generally in the early part of the present century. Though some of these cars are still in service, their construction was discontinued some years ago; they were not completely successful from the standpoint either of operation or of maintenance. When they are compared with successful cars of the present day, their limited success can probably be ascribed to two important factors: (*a*) excessive weight and (*b*) engine and transmission troubles. They weighed from 1000 to 1500 lb. per passenger when fully loaded, whereas the successful car of today weights about 600 lb.

During the summer of 1921, the American Short Line Railroad Association began an investigation of all the self-propelled rail motor-cars in this Country and in Europe, the first step being to send out a questionnaire to the 500 different member-lines of the Association that are located throughout the United States and Canada. Since the short lines and the branch lines have been the proving-grounds, more or less, for the different motor-cars brought forth in the last 20 years, we were able to acquire more complete and definite data as to their performance under actual service conditions than had theretofore been compiled. From this questionnaire we were also able to determine the demands as to seating-arrangement, capacity and the like, and deduce designs based on the average requirements of the short lines.

We augmented this information with our own personal investigation of a number of the cars offered, and attended numerous demonstrations, but the information given in answer to our questionnaire was based on day-in-and-day-out performance through the heat of summer and the cold of winter, rain and snow storms, and with the usual run of employes, instead of being a demonstration under the most favorable conditions under the supervision of a specially-trained operator. As a result, we were able to acquire performance records that were absolutely unbiased; and it will be interesting to note

[1] Manager of purchases, American Short Line Railroad Association, Chicago.

that one of the lines has a car that has made nearly 400,000 miles in practically continuous service and with remarkably low up-keep. This was built on a 2-ton truck-chassis with the addition of flanged wheels and a pivotal pony-truck.

Highway Motor-Trucks Adapted to Railroad Service

The field for self-propelled cars on short-line and branch-line railroads has been apparent for many years, but early attempts to supply this need were unfortunate in that they were not entirely satisfactory or successful; and the development was, therefore, seriously retarded. The first cars being more or less unsuccessful, the construction of all types of rail motor-cars was discontinued during the war, and their development was not revived until a few years ago. This was due largely to the rapid strides made by the automotive industry in successfully designing and building highway motor-trucks. The adapting of these vehicles to railroad service by applying flanged wheels revealed the possibility of economy when the weight was kept down and consequently a number of such cars were put into railroad service. The earlier ones, like the car previously mentioned as having made 400,000 miles, were merely motor-truck chassis equipped with flanged tires on the rear wheels, pivotal pony-trucks forward and a motorbus body for passengers and for a limited amount of baggage.

These six-wheel, motorbus-type cars weighed approximately 500 lb. per passenger-capacity and, with their successful truck-type engine, could be maintained and operated with the same ease and at less expense than could a highway truck. They could travel from 7 to 10 miles per gal. of gasoline, and the total cost of operating them averaged about 15 cents per car-mile, depending on the scale of wages. Although economical, they were not comfortable to ride in, and they were followed by the development of slightly larger cars of light weight that were equipped with the same proved automotive-type engine but with two pairs of four-wheel pivotal trucks and swing bolsters. This brings us up to the position of the industry at the present time.

Several very satisfactory cars are now on the market, the most successful, weighing about 28,000 lb., being capable of carrying 45 to 50 passengers and having suitable baggage-space. This weight, you will note, is slightly more than 550 lb. per passenger. The car is capable of making a maximum speed, under ordinary grade and track conditions, of 45 m.p.h., and can be accelerated from a state of rest to a speed of 35 m.p.h. in 1 min., and may be brought from this speed to a dead stop in 250 ft., when on a normally-dry rail.

Present State of the Industry

We have records of 135 roads operating 164 motor cars, of which 34 are on trunk lines and 130 on short lines. Many of these cars have replaced steam trains that were being operated at a cost far in excess of the passenger returns. Whereas the cost of operating steam trains averages about $1 per train-mile, that of operating a motor car does not exceed 25 cents per car-mile, even though trunk-line or standard wages are paid; and on short lines less than 100 miles in length, where the same wage-scale need not be followed, the cost is less than 20 cents per car-mile. For the last 15 years I have been closely associated with a short line 108 miles in length, on which a steam passenger-train was operated at a loss of about $3,000 per month. In June, 1923, we put the first motor-car into operation. It has proved a money-maker from the first day, notwithstanding the fact that we had not attempted to give passenger service for 2 years prior to that time. In August, 1924, the car was still running with the original engine and driving-units and appeared to be good for some months more without general repairs or overhauling. Table 1 is a condensed balance-sheet covering the operation of this car. Table 2 is a detailed operating-analysis for one complete year, July 1, 1923, to June 30, 1924. You will note that the average operating-cost per car-mile, including all charges, is 17.3 cents, whereas the steam-train cost was $1, or nearly six times as great. The total profit for the first year, with liberal depreciation, carrying-charges and the like, was $22,555.02, as against an approximate loss under steam-train operation of $36,000 per year. The total net-gain from motor-car operation was approximately $56,555.02 on an investment of $16,926, or more than 300 per cent. Our passenger service has been so successful that we have recently placed in service a car of similar size and capacity for handling package-freight and express, which, to my mind, is destined to become the largest part of the rail motor-car industry. I believe that the majority of American railroads are vitally interested in the development of self-propelled cars and that as different designs that will more nearly meet their individual needs are completed they will adopt them to supplant steam trains that under present conditions are being operated at a loss.

TABLE 1—OPERATING STATEMENT COVERING GULF, TEXAS & WESTERN RAILROAD MOTOR CAR CO. NO. 600 FOR 1 YEAR, JULY 1, 1923, TO JUNE 30, 1924

Daily Mileage, July 1, 1923, to Sept. 19, 1923		168
Daily Mileage, Sept. 20, 1923, to June 30, 1924		216
Total Miles Run During the Year		75,168
Fixed Charges, Including Interest at 8 Per Cent, Depreciation, on the Basis of 3 Years for the Power Unit and 10 Years for the Steel Body, Insurance and Similar Items	$4,258.32	
Operating Expenses	8,745.01	
Total Fixed Charges and Operating Expense		$13,003.33
Operating Expense Per Train-Mile, cents		17.3
Passenger Revenue	$29,119.97	
Mail Revenue	6,438.38	
Total Earnings		$35,558.35
Total Net Earnings, July 1, 1923, to June 30, 1924		22,555.02
Investment, Cost of Motor Car		16,926.00

The approximate mileage on which motor cars are being or have been operated is 8000. The number of steam trains that have been replaced is about 200. In all cases the service has been greatly improved, for no cinders or dirt annoy the passengers, and the ability to accelerate motor cars quickly enables the railroads to furnish more frequent service. Because of the fact that motor cars are a profitable investment, the managements are able to keep them in better condition than was the case with steam passenger-equipment that represented only continual losses.

Although a great sum of money has been expended in experimental work, part of it misdirected, the actual investment in serviceable rail-motor-cars today probably does not exceed $2,500,000. The steam-train investment necessary to provide the same service would very likely approximate from $8,000,000 to $10,000,000.

Advantages of Motorization

It is my belief that, as the development of motor cars proceeds, practically all branch lines and short lines will in time become motorized, and that even a considerable

mileage of local trunk-line steam-train service will be replaced with motor cars. Schedules may be arranged so as not to conflict with through-train service and, at the most important terminals, a plan might be worked out by which local motor-cars could be run into the business sections of cities over street-railway tracks.

Up to the present time, the limiting factor in the development of rail motor-cars suitable for all branches of service has been the inadequate power developed by the most approved type of truck engine, but it is reasonably certain that the solution of this problem is only a short way off. I am also of the opinion that before long internal-combustion engines will be available which will be capable of using a lower grade of fuel than gasoline. This will not only solve the problem of passenger service, but also will make available immediately a type of internal-combustion locomotive that can be successfully employed in handling the freight service on short-line and branch-line railroads on which an average train consists of not more than 10 or 15 cars. As the power of these engines is increased, some other form of transmission, electrical or hydraulic, will probably be necessary, inasmuch as some engineers claim that the limit of the present clutch and mechanical transmission system has about been reached. This, however, will not be a serious obstacle, and may prove an advantage.

It will doubtless be interesting to call attention to further economies, other than those directly accruing from the use of the self-propelled car or the internal-combustion locomotive. The complete motorization of a railroad, for example, would eliminate the necessity for water-stations, coaling-stations, roundhouse facilities and numerous other charges that have gone to make up the operating deficit so common on the average small railroad. Then, too, the decrease of track and road-bed maintenance brought about by the use of motor cars, as compared with that of heavier steam locomotives, is enormous, but, as yet, no accurate figures are available.

In concluding, may I say that, in my opinion, much of the credit for the present successful motorization of many railroads belongs to the members of this Society and to the automotive industry generally. We are looking to you for the further development of automotive equipment that can be installed in railroad cars of light weight with which operating deficits on a majority of short-line and branch-line railroads may be turned into profits.

TABLE 2—MOTOR-CAR OPERATING-COST ANALYSIS OF BRILL MODEL 55, GULF, TEXAS & WESTERN RAILROAD PASSENGER CAR NO. 600 FOR ONE COMPLETE YEAR, JULY 1, 1923, TO JUNE 30, 1924

Mileage and Passengers Carried		
Number of Trips Run During the Year		365
Daily Mileage, July 1, 1923, to Sept. 19, 1923 (Mineral Wells to Megargel and Return)		168
Daily Mileage, Sept. 20, 1923, to June 30, 1924 (Mineral Wells to Seymour and Return)		216
Total Miles Run During the Year		75,168
Revenue Passengers Carried During the Year		19,981
Average Daily Revenue Passengers		54.8
Non-Revenue Passengers Carried During the Year		1,703
Average Daily Non-Revenue Passengers		4.7
Total Sale of Through Tickets Beyond the Line		1,901
Average Daily Sale of Through Tickets Beyond the Line		5.2
Total Passenger-Miles for the Year		835,142
Average Passenger-Miles per Day		2,288
Average Length of Ride, miles		41.79
Fixed Charges		
Depreciation of Railroad Equipment Body, Estimated Life 10 Years Value of Body, $10,000.00		$1,000.00
Depreciation of Automotive Equipment Engine, Estimated Life 3 Years Value of Engine, $7,000.00		2,333.33
Interest at 8 Per Cent on the Average Investment		800.00
Insurance, per Annum		124.99
Total Fixed-Charges		$4,258.32
Average, per Month	$354.86	
Operating Expense		
Motorman, 75,168 Miles at 3.3 Cents per Mile and Overtime	$2,531.13	
Trainman, 75,168 Miles at 3.1 Cents per Mile and Overtime	2,367.86	
Passenger-Train Car-Repairs	135.01	
Motor-Equipment of Car	768.00	
Gasoline, 10,959 gal.	1,632.86	
Lubricants for Train Locomotives	305.25	
Other Supplies	16.10	
Train Supplies and Expenses	599.91	
Advertising	103.08	
Station Employees	197.28	
Injury to Persons	88.53	
Total Operating Expenses		$8,745.01
Average per Month	$728.75	
Total Fixed-Charges and Operating-Expenses		$13,003.33
Average per Month	$1,083.61	

Revenue from Operation			
Passenger Revenue for the Year			$29,119.97
Average Passenger Revenue per Month		$2,426.66	
Average Passenger Revenue per Day		79.78	
Mail Revenue for the Year			6,438.38
Average Mail Revenue per Month		536.53	
Average Mail Revenue per Day		17.64	
Total Passenger and Mail Revenue for the Year			$35,558.35
Average Passenger and Mail Revenue per Month		2,963.19	
Average Passenger and Mail Revenue per Day		97.42	
Total Passenger Revenue from Outbound Passengers		13,467.64	
Total Passenger Revenue from Inbound Passengers		15,652.33	
Cost and Revenue Statistics		Earnings	Expenses
Per Day, Passenger	79.78		
Mail	17.64	97.42	35.63
Per Train-Mile, Passenger	0.387		
Mail	0.086	0.473	0.173
Per Passenger		1.450	0.650
Per Passenger-Mile		0.035	0.016
Fuel			
Gasoline Used During the Year, gal.			10,959
Cost of Gasoline Used			$1,632.86
Average Cost per Gallon, cents			15
Average Mileage per Gallon			7
Profit and Loss from Operation			
Passenger Revenue for the Year		$29,119.97	
Mail Revenue for the Year		6,438.38	$35,558.35
Depreciation, Interest, Insurance, etc., for the Year		$4,258.32	
Operating Expenses for the Year		8,745.01	13,003.33
Total Profit for the Year			$22,555.02
Average Monthly Profit		$1,879.58	
Investment			
Cost of Motor Car			$16,926.00

Public-Utility Experience with the Motorcoach

By V. E. Keenan[1]

Automotive Transportation Meeting Paper *Illustrated with* Drawings and Photograph

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

ALTHOUGH street-railway managers have had very little experience with the operation of motorcoaches until the last 5 years they have been rudely awakened by the rapid increase in the number of independent operators and are beginning to realize that a new transportation era is at hand and that new standards in mass transportation are in demand. The delay in adopting motorbuses, while considered disastrous by some, in reality has given time to determine whether the new system is merely a fad or is due to the conditions in the labor market and to the rise in the cost of materials that have prevented the railways from extending their plants and their operations. In the period from 1917 to 1923, the number of licensed automobiles increased 300 per cent while, in the same period, the number of passengers carried by the street railways increased only 10 per cent; but both indicate the need of greater transportation facilities. The highways of the Country, of which only about 20 per cent are adequate for the operation of motorbus traffic, are rapidly reaching the saturation-point; and the traffic of the future will undoubtedly increase faster than will the construction of highways. The street-railway track-mileage of the Country already exceeds its present usefulness; consequently, no form of mass transportation other than the motorbus is capable of reaching out into this field.

Within the next few weeks approximately 16 per cent of the electric-railway mileage in Providence will be abandoned because it does not pay the cost of electric operation; and motorbuses will be substituted. The comparative cost of operation of motorbuses and electric-railway cars has been found to be 24.49 and 32.90 cents respectively. By substituting motorbuses this difference in operating cost will be taken advantage of. The difference in popularity and earning power of the two systems was exemplified during a recent 3-day holiday period, the receipts of the electric-railway cars showing a decrease of $465 and the motorbuses an increase of $778 over those of the corresponding period of the previous year.

About 3 per cent of the earnings of an electric-railway car are derived from the standing load. If motorbuses are to show a greater earning ability, a larger number of seats must be provided. The field for double-deck motorbuses is limited but the capacity of single-deck motorbuses should be increased. With a view to reducing the cost of operation and maintenance the suggestion is made that attention should be given to the operation of vehicles that are larger and at the same time simpler to maintain. Charts show the net cost of electric-railway and of motorbus operation, the tendency of electric-railway earnings to fall off and those of the motorbus to rise, the cost of mechanical maintenance of four different types of motorbus, and the increase in the registration of motor vehicles annually since the earliest days of the industry.

THE experiences gained within the last 5 years by public-utility companies in the operation of motorcoaches as a branch of the passenger-transportation business certainly present an interesting story. It should be realized that the various managements connected with the street-railway industry, with possibly three or four exceptions, knew nothing of conducting motorcoach business prior to this period. The rude awakening, given the industry by the horde of independent, unregulated and unreliable jitney and motorbus operators, without doubt served notice on the men directing the policies of various street-railways that a new era of transportation had come upon the Country. No doubt, the marvelous development of privately-owned automobiles has created a greater desire for individual transportation; and this desire, reflected in the volume of patronage enjoyed by the early jitney men, brought home a realization of the fact that higher mass-transportation standards were in demand.

After a delay of some 1 to 3 years by the various railway managements in different parts of the Country, it was finally decided to adopt this newer vehicle in the field of transportation, as known to the industry. From some quarters the thought was advanced that, by delaying the adoption of the motorbus, railway executives and managements were pursuing a disastrous course. Personally, I do not feel so but rather defend this stand by pointing to the possibility that it would be simply a fad, a timely adventure on the part of independent operators to reap a harvest in revenue, which was made possible as a result of the street-railways' inability to expand their plants and operations because of the sharp rise in the cost of materials and labor that extended over a period of several years prior to the advent of the jitney.

The Increase of Traffic

While privately-owned automobiles have increased in number from slightly more than 5,000,000 cars, registered in 1917, to 15,000,000 cars in 1923, the number of passengers carried by the electric railways during the same period increased from 14,500,000,000 to 16,000,000,000. In the former case, the increase was 300 per cent; in the latter, 10 per cent. One of two deductions is apparent, either that the automobile industry is neglecting a portion of its market or that the desire for and need of transportation is becoming greater, as is evidenced by the increase in both cases. We feel that the latter is true.

Nearly everyone agrees that the highways in all parts of the Country are approaching the saturation-point and that this point will be reached before the demands for transportation have been satisfied; although highway de-

[1] Superintendent, bus divison, United Electric Railways Co., Providence, R. I.

velopment and improvement will surely increase in the future, the desire for transportation will also increase. It has been estimated that 80 per cent of the highways of the Country are inadequate for motorized traffic. Thirteen per cent of the total, or about 400,000 miles of roads, have been improved to some extent with surfacing; the total for paved roads does not reach 30,000 miles. With a total road-mileage of approximately 2,860,000 miles as a basis for the volume of traffic that will avail itself of improved roads, it is hard to imagine any form of mass-transportation carrier, other than the motorcoach, that will reach out into this field. The street-railway track-mileage of the Country already exceeds its present usefulness.

Motorbuses Replace Electric-Railway Cars

In our own case at Providence, we have a total of 350 miles of track, 59 miles of which we expect to abandon within the next few weeks and to substitute motorbuses, simply because this mileage does not pay the net cost of electric operation. By net cost of operation, we mean that such items as cannot be directly charged to the operation of the unit, but can be charged to the volume of the business, have been eliminated. As a result of this elimination, we have arrived at a cost figure of 32.9 cents per electric car-mile. By substituting the net cost of motorbus operation, which in our case is 24.49

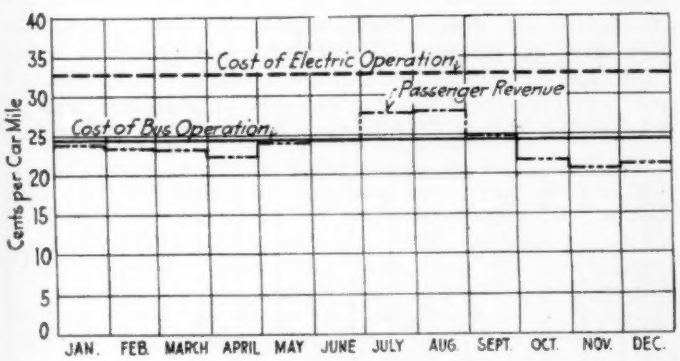


Fig. 1—Passenger Revenue per Car-Mile of Four Suburban Electric-Car Lines

The Upper Horizontal Line Represents the Net Cost of Electric-Car Operation and the Lower One the Net Cost of Bus Operation. The Broken Line Shows the Earnings per Car-Mile for the Various Months of 1923. Only Two Months, July and August, Did the Earnings Exceed the Net Cost of Bus Operation and the Earnings for the Entire Year Fell Completely below the Cost of Car Operation

cents, it will be possible to effect an economy equal to the difference between these two costs.

Fig. 1 is a combined graphic presentation of the passenger revenue per car-mile of four suburban car-lines. The top horizontal line represents the net cost of electric-car operation; the lower horizontal line, the net cost of motorbus operation. The earnings per car-mile for the various months of 1923 are indicated. It will be seen that in only two months of the year, namely, July and August, do the earnings exceed the net cost of operation of the motorbus and that the earnings for the entire year fall completely below the cost of electric-car operation. Of course, a great many street-railways must, of necessity, operate non-paying lines, being desirous not only of obtaining a monopoly of the business but also of causing the non-paying lines to feed into and supplement the system as a whole. Electric car-lines that come under this classification are rapidly being abandoned and motorbuses are being substituted for them. In some instances the substitution of motorbuses has actually increased the gross earnings of the lines.

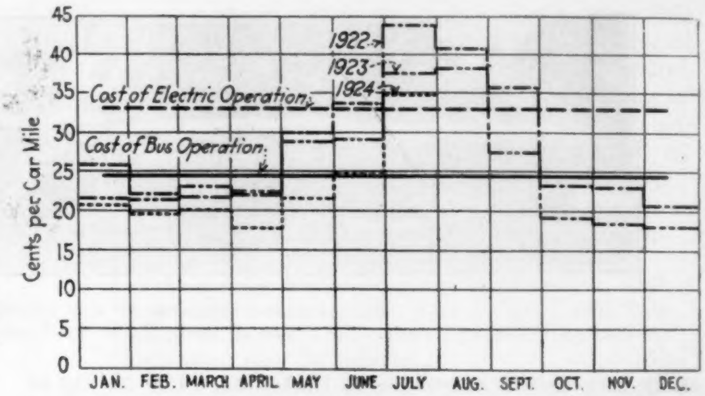


Fig. 2—Passenger Revenue per Car-Mile of a Suburban Electric-Car Line for Three Years

As in Fig. 1 Horizontal Lines Are Used To Represent the Net Costs of Bus and Car Operation and the Revenue per Car-Mile for 1922, 1923 and 1924 Is Indicated by Various Kinds of Broken Line. The Tendency of the Revenue of These Lines To Decrease Is Brought Out Strikingly. As Extreme Losses Cannot Be Sustained, the Substitution of the Motorbus Not Only Reduces These Losses But Also Offers a Possibility of Increasing the Gross Revenue

Comparative Earning-Power

An illustration of the earning-power of the motorbus as compared with that of the street-railway car has been brought to our attention very plainly during the last few months. For three days surrounding a holiday, the combined earnings of motorbuses and street-cars, running between a large city in Rhode Island and an amusement resort, exceeded the earnings for the same days of the previous year by some $314. Street-cars and motorbuses run practically parallel for the entire distance. The street-car receipts fell off to the amount of $465.25, while the motorbuses showed an increase in earnings of $778.22. This interesting comparison shows plainly the increasing popularity of the motorbus.

Fig. 2 illustrates the tendency of suburban electric car-lines to fall off in revenue. Here we have displayed the earnings by months for three successive years, namely, 1922, 1923 and 1924. This one representative line shows a common condition existing in many other suburban lines. Obviously, extreme losses cannot be sustained and the motorbus, when used as a substitute, not only reduces the losses but offers a possibility of increasing the gross receipts.

In Fig. 3 is shown graphically the history of motorbus operation by the United Electric Railways Co. of Providence. Operation was begun July 3, 1922, and has grad-

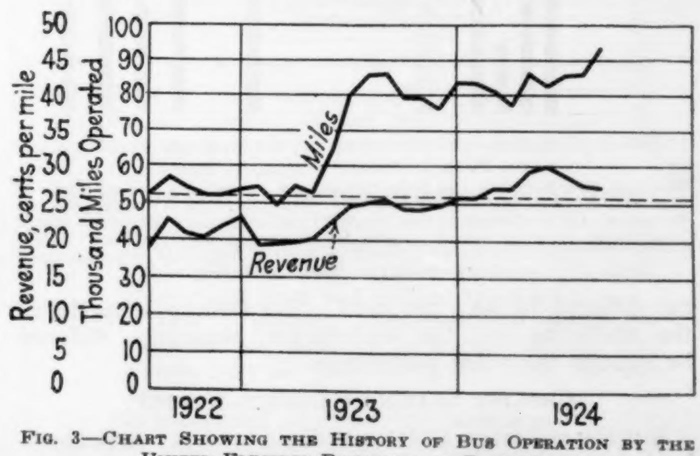


Fig. 3—Chart Showing the History of Bus Operation by the United Electric Railways of Providence

Operation Was Commenced on July 3, 1922, and Has Gradually Increased Its Scope throughout the Period. The Gradual Climb of the Revenue Line until Its Final Rise in the Earlier Months of This Year over the Cost of Operation Shows the Ability of Bus Operation To Pay Its Way

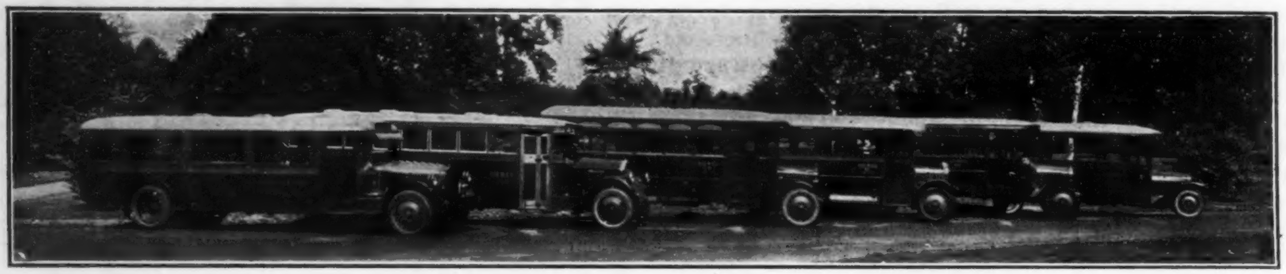


FIG. 4—BUSES OPERATED BY THE UNITED ELECTRIC RAILWAYS OF PROVIDENCE
One of Each of the Six Types Now in Service Are Shown

ually increased its scope since that time. The ability of the operation to pay its way can be noticed in the gradual rise in the revenue line until it finally climbed over the cost of operation in the earlier months of this year. If motorbuses are to earn money, a point that was very severely disputed a few months ago, we believe that the motorbus should be capable of carrying greater loads.

TABLE 1—DIVISION OF REVENUE OF THE UNITED ELECTRIC RAILWAYS CO. FOR THE YEAR 1923

	Electric Car	Motorbus	Difference, Per Cent
Revenue	$7,806,870.66	$199,331.55	2.55
Mileage Operated	15,935,901	847,872	5.32
Revenue per Mile, cents	48.90	23.51	48.10
Seating Capacity	52	25	48.10
Car-Hours Operated	1,776,547.62	77,798.57	2.31
Average Speed, m.p.h.	8.99	10.87	
Investment	$25,898,149.80	$304,043.89	1.17
Revenue Obtained for Investment, per cent	3.01	65.5	

Table 1 is a comparison of last year's operation of the motorbus and the electric car on our property. The earnings per car-mile of the motorbus and the electric

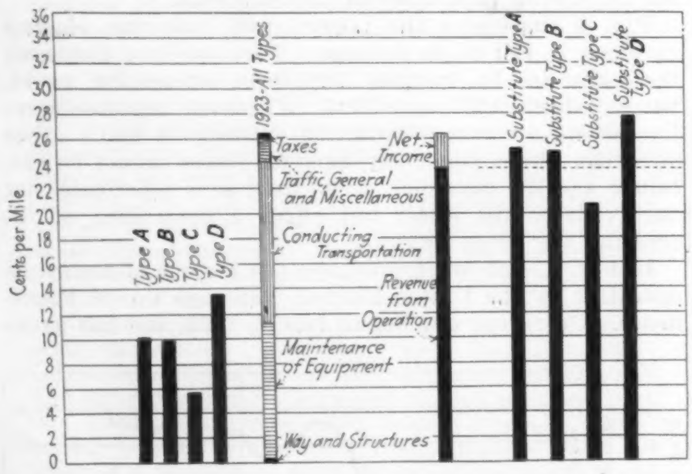


FIG. 5—CHART SHOWING THE COST OF MECHANICAL MAINTENANCE ON FOUR DIFFERENT TYPES OF BUS
The Relation between the Selection of the Proper Make and Type of Equipment and the Net Profits Is Brought Out. Projecting the Revenue Line through the Four Cost Columns at the Right Illustrates Exactly What Might Be Expected in the Way of Net Profits if This Particular Operation Had Completely Standardized on Each of the Various Makes

car differed by 48.1 per cent. The seating capacity of the motorbus and the electric car, strangely, differed by exactly the same percentage.

GREATER SEATING CAPACITY NEEDED

But the motorbus under our State laws is handicapped by being limited to a seated load, whereas practically 3 per cent of the revenue obtained by the electric car comes from standing passengers. We have no argument with the theory behind the seated load, provided, of course, that the differential in fare is proportionate; but, with a keen desire to make the motorbus show a substantial net earning-ability, it is apparent that a greater number of seats must be supplied. In our particular case, the field for double-deck operation is limited; as a matter of fact, all our motorbuses are of the one-man single-deck type. Our management feels very strongly that single-deck motorbuses should be built to carry a load equal to that of a single-deck car. Although this figure is closely related to street width and the ability of a vehicle to flow smoothly with the traffic, it is not outside the realm of possibilities that motorbuses seating 35 passengers will appear in the early future.

One each of six different types of motorbus that we operate are shown in Fig. 4. From the passenger's standpoint one development within the last 2 years has been most pronounced. Present-day equipment is being built that duplicates the riding-qualities, vision, comfort and acceleration of the better class of passenger car on the market today. While this development in comfort

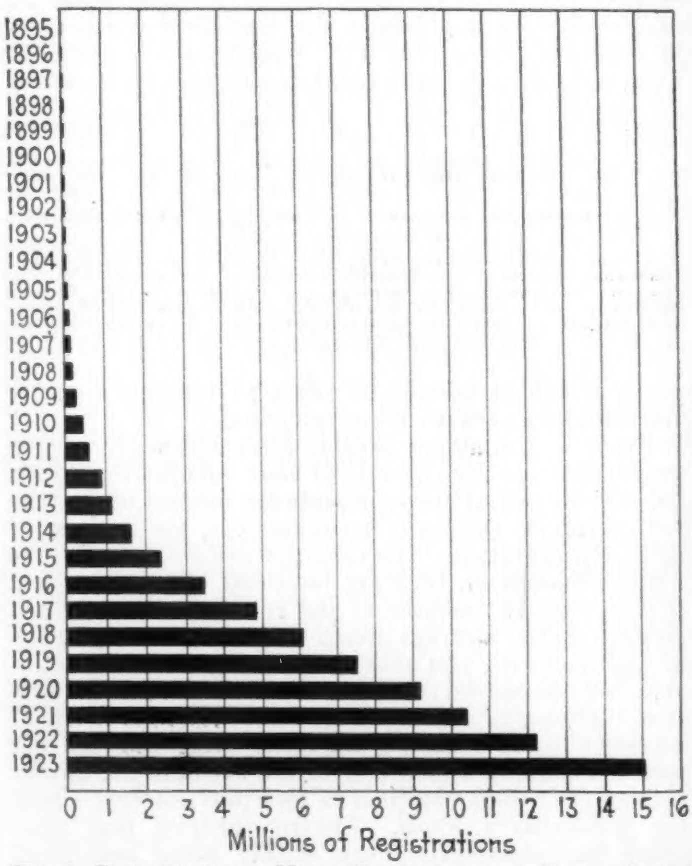


FIG. 6—REGISTRATION OF MOTOR VEHICLES IN THE UNITED STATES
A Study of This Chart Will Indicate Clearly How Automotive Vehicles Support Entire Industries and Can Make or Break Them through the Demands They Directly or Indirectly Create and the Changes in Demand Which They Bring About

and acceleration has been most welcome, very little apparently has been done in the way of reducing the costs of operation.

Fig. 5 displays graphically the cost of mechanical maintenance on four different types of motorbus. It is plain to see that the whole matter of net profits is wrapped up in the selection of the proper type and make of equipment. A projection of the revenue lines through the four cost columns at the extreme right illustrates exactly what might have been expected in the way of net profits if this particular operation had been completely standardized on each of the various makes. Although it is difficult to advance a theory as to what the engineers of railway equipment may have in the way of developments that will reduce the cost of operation, we feel that the electric-railway industry is relatively old, whereas the automotive industry is comparatively new. The rise of the latter, both in volume and popularity, has not been due to any economic cause; it is wholly reasonable, therefore, to believe that engineers designing equipment in the future will give more attention to the cost of maintenance than has been apparent in the past. This point I feel certain, cannot be stressed too greatly.

As a result of our experience, we find vast differences in the cost of operating various makes of equipment. Externally and theoretically no reason exists for this differential. As a matter of face, however, as evidenced by operation, great differences in cost do exist; and, although we do not advocate a complete abandoning of existing units by the various manufacturers, we respectfully submit the suggestion that more thought and attention be given to the following points:

(1) Let the transportation industry operate larger vehicles that will give an opportunity for earning greater profits
(2) Let the transportation industry have vehicles that are simpler to maintain, that is, units that can truly be classed as accessible, so that the cost of operation may be reduced

As a closing thought, I should like to refer to Fig. 6, a record of the increase in the registration of motor vehicles since the earliest days of the industry. One cannot intelligently analyze the facts here displayed without realizing the enormous growth in the desire not only for transportation, but also for the type of vehicle that shall supply this need. Do not hesitate for one moment, but believe that, if the riding public actually desires to increase this growth further, the managements of the various mass-transportation companies will supply the vehicles with which to render the proper kind of transportation.

HIGHWAY TRAFFIC IN NEW YORK CITY

In New York City alone about 265,000 passenger cars, 79,000 motor trucks and 20,000 omnibuses were in use in 1923. Comparatively little change in the proportion of each of these during the past few years has occurred. In the entire city the number of persons per motor vehicle was about 45 in 1916, and in 1923 this figure had been reduced to about 16 persons per vehicle, while those for the different boroughs varied from about 9 to 20 persons per vehicle. As might be expected, the number of persons per vehicle was smaller, or the number of cars per capita larger, in the less densely settled portions of the city. The large areas of densely settled districts make it improbable that this ratio would ever reach as low a figure in them as in the less densely populated regions. It appears that in 1930 the number of persons per motor vehicle will be about 8 or a total in New York City of about 835,000 vehicles, based upon an estimated population of 6,700,000. By the year 1950, the number of persons per vehicle will probably have become stable, and from that date the number of vehicles will more closely follow the population, provided, of course, that some other form of transportation does not supersede the automobile. Assuming five persons per motor vehicle in the year 1960, a conservative conclusion from the curve showing the change in this factor, at that date approximately 2,100,000 motor vehicles will be in operation within New York City.

Assuming that it is necessary to allow for one lane of standing vehicles along the curb in front of any business property, and using the above capacities, it is estimated that the total maximum possible hourly traffic under existing conditions, on all north and south avenues in the neighborhood of 48th Street is 29,225 vehicles per hour, or only about 125 per cent of the actual traffic in 1923. On all avenues in the neighborhood of 28th Street, the same maximum possible traffic is estimated at 29,100 vehicles per hour, or 195 per cent of the actual 1923 traffic.

It would seem safe to estimate the cost of traffic congestion in Manhattan Island at $500,000 per day, and the cost in the whole region to approximate $1,000,000 per day. The increasing stringency exercised with reference to parking-time points to ultimate conditions when no parking will be permitted on any north and south main thoroughfare in Manhattan Island, and in similar main streets in other parts of the region. Were no parking to be permitted on any north and south avenue in Manhattan, the resulting capacity for traffic would be increased to 150 per cent of the present use, and, were certain changes to be made in the carrying capacity of some of the avenues by the removal of elevated and trolley tracks, the simple prohibition of parking would make possible the doubling of present use.

Among the plans that have been put forward from time to time for relieving traffic congestion on Manhattan Island, one of the most interesting and far-reaching in the character of its proposals was that submitted to the Committee on the Regional Plan by a group of architects under the chairmanship of Harvey W. Corbett. The ultimate development of this proposal would mean the creation of streets in three tiers, in which all the trolley or rapid-transit lines would be placed underground, the present street-level would be given over to free wheeled vehicles, and pedestrians would be provided for at the present second-story level.

Causes of Congestion

The causes of traffic congestion include:

(1) Narrow streets inherited from former times
(2) Building heights too great for the capacity of the adjacent streets
(3) The lack of zoning with reference to use, height and bulk of buildings, so as to preclude the creation of traffic congestion caused by the use of the streets by such building tenants, especially at morning, noon and evening hours
(4) The lack of platting ordinances that would prevent the creation of new subdivisions with streets that are too narrow for their ultimate use
(5) The inadequacy of arterial thoroughfares
(6) The lack of a comprehensive plan within which can be included each of the several creative and preventive measures suggested above

—From a paper by E. P. Goodrich and H. M. Lewis, presented at conference on traffic problems.

Trailers and Demountable Bodies for Motor Transportation

By H. W. Howard[1]

Automotive Transportation Meeting Paper — *Illustrated with* Drawings and Photographs

ABSTRACT

UNDER fair conditions, the capability of good motor-trucks and good tractor-trucks, for almost continuous operation, is from 100,000 to 300,000 miles, according to the author, who interprets "almost continuous operation" to mean a service of 20 hr. per day, 6 days per week and 280 days per year, hauling loads that approximate the load capacity of the vehicle. Yet time-studies have proved that the average performance of motor trucks with load is usually 4 hr. or less per day for the 280-day yearly period, a truck usefulness of only 20 per cent of its continuous-performance ability. Characterizing this as very inefficient transportation, the author says that few motor-truck operators realize the importance of the lost-time factor, discusses the subject of time lost in service and implies that motor-truck traffic-managers should give earnest consideration to the determination of what constitutes a satisfactory day's work for the vehicle. He believes the remedy to be in the improvement of the type and size of the vehicle, the loading and unloading conditions, the type of body, the auxiliary equipment, routing and dispatching, cost records and maintenance methods.

The use of tractor-truck trailers is advocated and the respective merits of two and four-wheel trailers are set forth. The three methods of semi-trailer hauling, using one, two or three such vehicles behind a tractor truck, are explained, and the advantages of each are specified. A motor-driven vehicle specially designed to load, haul and unload sugar-cane is illustrated and described.

ALL enterprise has been assisted to a high state of development by some form of engineering. This is notably true of truck building and will prove equally true of truck usage. The purpose of engineering is the attainment of better results. It is not directly interested in the sale of anything. Engineering invents, investigates and recommends impartially, on a basis of conclusions founded on fact. No details are too small for its consideration. It is successful according to the soundness of its advice to the interest it would serve. Transportation engineering does not constitute an exception to these rules. It seeks to serve the common interest of the truck user, the builder and the public by promoting more successful transport.

Under fair conditions, good motor-trucks and good tractor-trucks are capable of operating almost continuously for from 100,000 to 300,000 miles. By "almost continuously" I mean 20 hr. per day, 6 days per week and 280 days per year; and by "operating" I mean operating with loads approximating capacity. This is about all that should be expected of a truck from the standpoint of continuous performance, and it is an achievement worthy of note when compared to other mediums of transportation. Time-studies covering a large number of installations throughout the Country show that the average performance of motor trucks with load is usually 4 hr. or less per day, 6 days per week, 280 days per year. This is a truck usefulness of only 20 *per cent of its continuous-performance ability.* Certainly, this is not efficient transportation. Too much time is lost.

The Lost-Time Factor

The amount of work that motor equipment can perform depends largely upon the efficiency with which it is handled. Few truck operators realize the importance of the lost-time factor and what it is costing them every day. How many traffic managers have set out to study first what constitutes a satisfactory day's work for a truck? How many traffic managers have ridden all day on their delivery vehicles, making time-studies of the vehicle, the driver and the helpers? The subject of the lost-time factor is worthy of earnest consideration. It usually contributes more toward operating costs of motor vehicles than do the items of depreciation, repairs, gasoline and the like all added together.

The Remedy

The best way to improve this situation is to make a time-study of the truck's operation. An analysis of the time during which the truck is not in motion will show quickly why the truck is not earning more money. This unproductive time should then be reduced to the minimum by endeavoring to improve the loading and unloading conditions, as well as by eliminating the other delays that are made apparent by the time-study. This will permit the operator to arrive at a standard trip-time against which the daily record of operations should be checked.

As a basis for comparison of trips, a standard should be established covering (*a*) average loading-time, (*b*) average unloading-time and (*c*) average running-time per mile, taking into consideration traffic delays and congestion. This gives an exact basis for figuring the time required for any length of trip. A definition of a day's work should not be conceived by the traffic manager at his office, but should be determined by studies of the actual operations.

In making studies of individual cases, it has been found that the lost-time factor can be reduced, other savings effected and, therefore, hauling costs lowered by improving upon the following important points:

(1) Type and size of vehicle
(2) Loading and unloading conditions
(3) Type of body and auxiliary equipment
(4) Routing and dispatching

[1] Transportation engineer, General Motors Truck Co., Pontiac, Mich.

(5) Proper cost-records
(6) Maintenance methods

Trailers

Let us now consider how trailers can help to reduce the lost-time factor and lower hauling costs by improving upon some of Items 1 to 6. Trailers have been used for years. In some few parts of the United States they are now used in large numbers. However, taking the Country as a whole, comparatively few trailers are in service. This situation exists for a number of reasons. Some of the principal ones are (*a*) the lack of widespread knowledge of the possibilities of trailer use, (*b*) the lack of an ideal power-unit for trailer operation and (*c*) the early development of the four-wheel trailer rather than the semi-trailer.

Under certain conditions, trailers of different types will reduce hauling costs by as much as 50 per cent. They require a smaller initial investment per ton of carrying capacity than trucks because of a reduction in the number of engine units required, they practically eliminate time lost in loading and unloading and enable loads up to 15 tons to be transported without violating legislation regarding road loads.

Trailers increase the hauling capacity of motor trucks by utilizing the reserve or excess power of the engine and by saving standing time. A motor truck, like a horse or a locomotive, can draw more than it can carry. It is powered to ascend steep grades and to go through heavy mud with full load. Under ordinary conditions it utilizes only a fraction of the full power of the engine. As our highways are improved, the field for trailers is enlarged in direct ratio.

Trailers Protect the Road

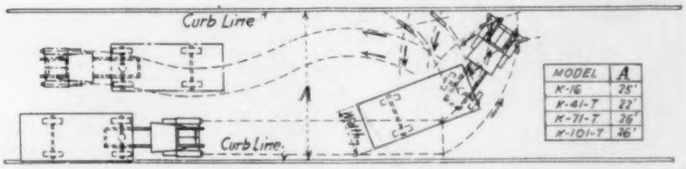
The capacity of carriers to handle large quantities of materials per unit is a potent factor in determining the economic sphere of each form of transportation. Consequently, the tendency is to use motor trucks of the larger sizes where a heavy tonnage is to be moved. State legislatures and highway authorities seek to combat this tendency in their efforts to prevent the rapid destruction of expensively built highways.

The serious problem confronting the Country is to find where the descending curve that represents decreased haulage-costs crosses the ascending curve that represents increased road-maintenance. This is a matter of public economics, because the public pays the bill for transportation as well as for highway work. The economic sphere of motor-vehicle use ends at that point at which the value it adds to commodities ceases to justify the cost of transportation by that means.

State legislatures are seeking to prevent concentration of excessive weight by limiting the gross weight of vehicles, the total weight on each axle and the load per inch of tire width. Such legislation makes it clear that the intention is to prevent undue concentration of weight on a small section of the road surface. This situation can be met and, at the same time, an economic volume of tonnage can be handled by hauling a given load on 6, 8 or 10 wheels, using one of the trailer combinations.

Semi-Trailers or Four-Wheel Trailers?

The question as to what constitutes the most economical and practical equipment depends entirely upon the conditions surrounding each haulage problem. A careful survey and analysis of the entire situation is the first step. The system that shows the lowest handling-cost per unit is the best. This question can only be answered



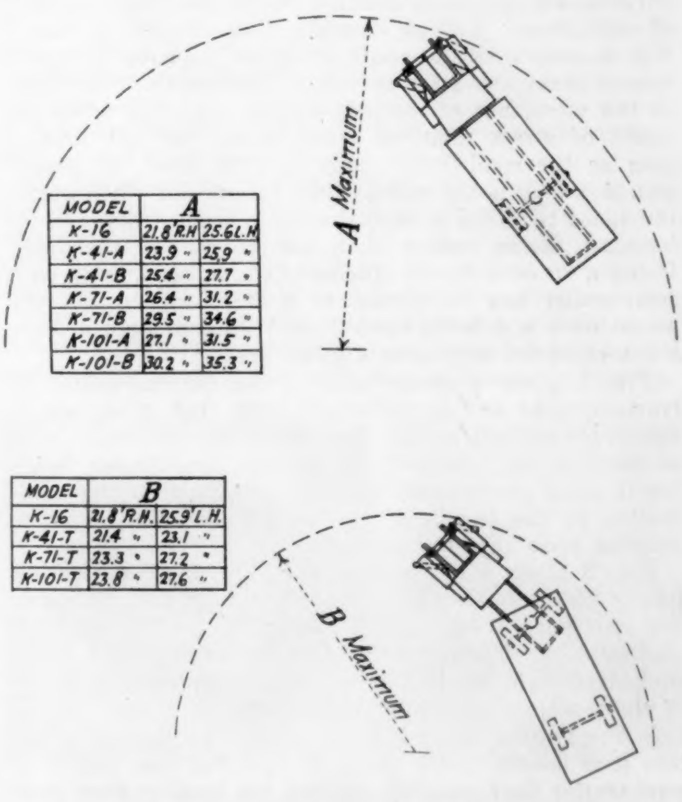
MODEL	A
K-16	25'
K-41-T	22'
K-71-T	26'
K-101-T	26'

Fig. 1—Turning a Tractor-Truck and a Semi-Trailer
The Complete Turn Is Made in Two Backing Operations. In All Movements after Starting To Make the Turn the Front Wheels Should Always Be in the Full Cramped Position. The Width of Street *A* Required To Make the Turn in Two Backing Operations Varies from 22 to 26 Ft., but If Necessary, on Account of Limited Space, the Unit Can Be Turned in a Street That Is 2 Ft. Narrower by Additional Backing Operations

here by outlining the fundamental principles involved. Their application to any particular case should be made by an experienced transportation-man.

At this point the question arises whether to use semi-trailers or four-wheel trailers. Four-wheel trailers are harder to handle at the loading dock than are semi-trailers. It is more difficult to back them and much more room is required in which to maneuver them. When a truck with four-wheel trailer is used, the truck naturally must stand idle while it receives its load. This ties up the expensive powerplant and eliminates the truck and the four-wheel trailer from consideration on many jobs.

The four-wheel trailer is effective in inter-city work. The truck and the trailers can be loaded simultaneously at different points and can then be assembled into one road-train and carried as such to its destination. Here again, if necessary, the loads can be deposited at different unloading-points. In certain cases within cities



MODEL	A	
K-16	21.8' R.H	25.6 L.H
K-41-A	23.9 "	25.9 "
K-41-B	25.4 "	27.7 "
K-71-A	26.4 "	31.2 "
K-71-B	29.5 "	34.6 "
K-101-A	27.1 "	31.5 "
K-101-B	30.2 "	35.3 "

MODEL	B	
K-16	21.8' R.H.	25.9' L.H.
K-41-T	21.4 "	23.1 "
K-71-T	23.3 "	27.2 "
K-101-T	23.8 "	27.6 "

Fig. 2—Comparison of the Turning Radius of Tractor-Trucks and Semi-Trailers with That of Standard Motor-Trucks
This Chart Is Based upon the Assumption That the Turn Is Made without Any Backing Operations. Here the Advantage Is with the Tractor-Truck and Semi-Trailer, Particularly If It Is Borne in Mind That the Wheelbase of the Semi-Trailer or the Length of the Semi-Trailer Body Has No Bearing upon the Turning Radius. The Maximum Radii of Right and Left Turns with Different Models Are Given in the Illustration

MODEL	A	B	C	D	E
K-16	132"	302"	14'	122"	186"
K-41-T	127	325	16	122	212
K-71-T	138	363	18	120	238
K-101-T	138	363	18	120	238

MODEL	A_1	B_1	C_1
K-16	132"	215"	10'
K-41-A	146	241	12
K-41-B	158	265	14
K-71-A	163	267	14
K-71-B	187	291	16
K-101-A	163	267	14
K-101-B	187	291	16

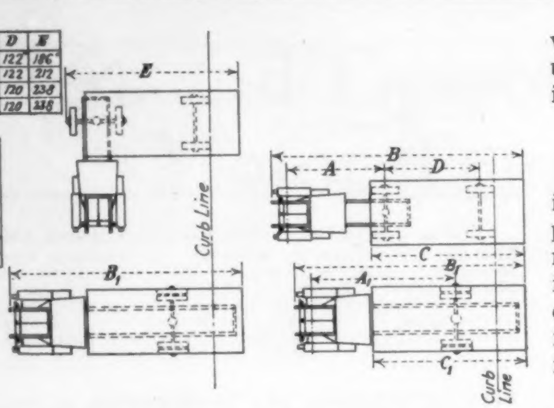


FIG. 3—COMPARISON OF THE OVERALL PROJECTING LENGTH OF TRACTOR-TRUCK AND SEMI-TRAILER WHEN AT CURB OR LOADING DOCK WITH A TRUCK IN THE SAME POSITION

The Truck Has a Slight Advantage when Backed Straight Up, But If the Tractor Can Be Turned around at an Angle, the Advantage then Rests with the Tractor and Semi-Trailer Combination. In Limited Quarters the Rear End of a Semi-Trailer Body Can Be Spotted against the Loading Dock More Easily than Can a Truck with Approximately the Same Size of Body. After the Semi-Trailer Has Been Spotted, the Tractor Will, in Most Cases, Move On To Pick Up Another Semi-Trailer and in This Event, the Space Occupied by the Semi-Trailer Is Much Less than That Taken Up by a Motor Truck

an efficient operating schedule can be devised for four-wheel trailers. On some haulage jobs on perhaps 2 days per week the tonnage will be too large for the regular equipment. In such cases a four-wheel trailer can be hooked on to take care of the peak load.

ADVANTAGES OF THE SEMI-TRAILER

A six-wheel vehicle is easier to handle than a motor truck having the same size of body. This statement will surprise anyone not familiar with the handling of a unit of this kind. Let us consider this subject in detail. Fig. 1 deals with the width of street required to turn a tractor-truck and a semi-trailer. The length of the body, or the wheelbase of the semi-trailer, does not affect the width of street required in which to turn the unit so long as the semi-trailer body is 2 ft. short of dimension *A*, which is the width of the street. In other words, the space required to turn the motor-truck tractor is the limiting factor rather than the length of the body. Using a 10 or a 15-ton tractor-truck, a 24-ft. body on a semi-trailer can be turned in a 26-ft. street, but one would have a difficult time there trying to turn a 5-ton truck equipped with even a 16-ft. body.

Fig. 2 gives a comparison of the turning-radius of tractor-trucks and semi-trailers with that of standard-wheelbase motor-trucks. Here again the difference is all in favor of the tractor-truck and the semi-trailer, bearing in mind particularly that the wheelbase of the semi-trailer, or the length of the semi-trailer body, has no bearing upon the turning-radius.

Fig. 3 gives a comparison of the over-all projecting length of tractor-trucks and semi-trailers and of standard-wheelbase trucks when backed up to the curb or loading dock. The difference in favor of the truck when backed straight up is slight; and a difference in favor of the tractor semi-trailer exists when it is possible to turn the tractor around at an angle. In limited quarters it is usually much easier to spot the rear end of a semi-trailer body squarely against the loading dock than in the case of a truck with a body anywhere near the same size. In most cases, after the semi-trailer is spotted, the tractor will move on to pick up another semi-trailer, in which event the semi-trailer, of course, will take up much less room than would a motor truck.

Ample space must be assured at loading docks if four-wheel trailers are to be used. Six-wheel trailers can be used wherever motor trucks are now being operated, and, in most cases, wherever a wagon can be spotted.

SEMI-TRAILER SAVES IN LOADING AND UNLOADING

One of the greatest advantages of the semi-trailer is in reducing the standing time of the powerplant. The powerplant represents a much larger investment in money than does a semi-trailer, and its earning power is very largely dependent upon the number of miles it can travel in a day. If it is held up a large portion of its time waiting for a load to be put off or on, its earning power is decreased greatly.

Semi-trailers are flexible equipment, offering many methods of operation suited to the conditions of the particular haulage work in hand. By selecting the proper semi-trailer method, profits of operation are made greater by both increasing the loads carried and reducing the time lost in loading and unloading.

SEMI-TRAILER HAULING

Three different methods of semi-trailer hauling exist, and each is adaptable to different conditions. In the first method, the semi-trailer is used continuously with a single tractor-truck. Although it is possible to disconnect at any time, this is not done often. In this case the purpose of the semi-trailer is to increase the tonnage capacity of the powerplant. For example, if 5 tons is the load to be carried, the tires, bearings, springs, frame and fifth wheel of the semi-trailer will have a combined pay-load capacity of 5 tons, whereas the tractor-truck's tires, bearings, springs and frame will have a pay-load capacity of only 2 tons, the amount of load that is transferred to it from the semi-trailer through the fifth wheel.

The two-semi-trailer method is that in which two semi-trailers are used in conjunction with a single tractor-truck. This means that the semi-trailers must be disconnected from the tractor-truck at frequent intervals and, therefore, supports are provided on each semi-trailer. This method is used most commonly in work in which a long time is required to load but only a short time to unload, or the load is taken off in small lots at different points. The first case usually obtains in the hauling of loose materials in dump bodies and the second in the delivering of package goods from a warehouse to various stores or other points.

Hauling from warehouse to stores is one of the most common uses for motor vehicles. Hundreds of lines of business require haulage of this kind and, in every case, the two-semi-trailer method is worthy of serious consideration. By the elimination of lost time on the part of the truck, the two-semi-trailer method offers the cheapest solution in the vast majority of cases of this kind.

The three-semi-trailer method involves the use of three semi-trailers in connection with a single tractor-truck. The method is particularly adaptable to conditions that require considerable time in both loading and unloading, the entire load being put on at a single point and likewise taken off at a single point. Such conditions prevail in the transportation of goods from a factory to a warehouse or a freight-station. While one trailer is being loaded at the factory, another is being unloaded at the warehouse and the third is in transit.

SHORT-HAUL INTER-PLANT TRAILERS

Tremendous savings often can be made on short hauls by using tractor-trucks with a number of trailers. Where the hauls are very short, as in inter-plant work,

the powerplant will be kept moving by a dispatcher who shifts trailers from one loading-platform to another. As showing the possibilities of this type of work, an installation at a large plant in Ohio is of interest; it would be hard to find a better illustration of what the efficient operation of tractor-trucks and trailers will do toward reducing hauling costs.

Before the installation of tractor-trucks and trailers, this company was using 36 trucks, each having a driver and a helper. These trucks were used in inter-plant hauls and between the various plants and the railroads. At present, its equipment consists of 25 semi-trailers, 15 four-wheel trailers and 4 tractor-trucks. They are handling more tonnage than the 36 trucks handled. Only 18 men are used, including platform men, tractor drivers and helpers, as against 72 drivers and helpers under the old system. It is readily apparent what a tremendous saving is made by the use of the tractor-trailer system. The 4 tractor-trucks are kept on the move constantly. The efficiency of the whole installation depends largely upon the dispatcher, who is in constant touch with the drivers and keeps them moving from point to point, depending upon telephone advices as to what trailers are ready to be moved.

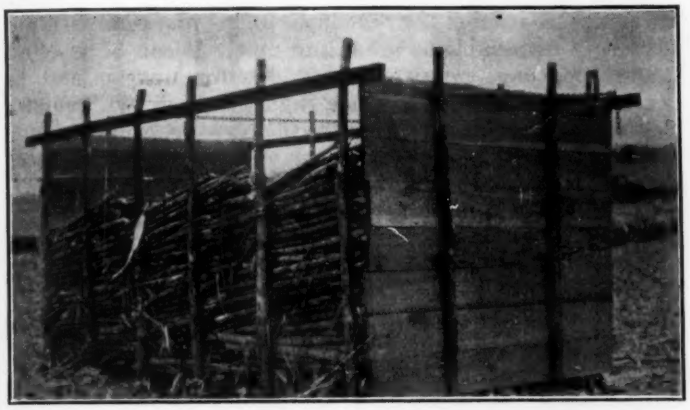


Fig. 4—A Bed Partially Loaded with Sugar Cane
These Beds Are Open Crates That Are Placed in the Fields for Loading by the Cane Cutters or a Special Loading Crew. When Filled the Portacana, Which Is a 5-Ton Truck Chassis Equipped with Special Loading Mechanism, Is Backed to within 15 or 20 Ft. of the Loaded Bed

Special Uses for Trailers

Trailers broaden the field of the motor truck by enabling it to transport products that cannot be carried on the machine itself. Large castings, stationary engines, electrical transformers, steam boilers, single blocks of building stone and similar objects weighing 10, 20 and even 30 tons are hauled quickly, economically and without damage to the highways, by the use of trailers. Timbers, poles, steel girders, iron pipe, bridge spans and other things from 20 to 65 ft. in length are commonly hauled by motor truck and pole, or extension, trailers.

The cost of hauling very light articles is greatly reduced by the use of trailers. Empty boxes and barrels are of small value as compared with their bulk and to haul them on motor trucks alone is unduly expensive. Any motor-truck has ample power to haul several times as many boxes, or barrels, as can be loaded in its own body. The same thing applies to automobile bodies, furniture and similar materials.

Removable Bodies

The removable body is another method of reducing the lost-time factor of the power unit. Various types of separate body have been developed in recent years. A number of these have proved to be fairly successful. This field is worthy of further investigation.

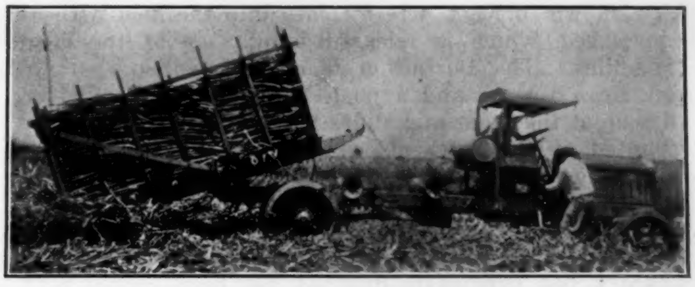


Fig. 5—Hoisting the Loaded Bed
The Cable from the Winch on the Portacana Is Fastened to the Hook on the Front of the Bed and as the Winch Pulls the Cable Taut, the Chassis Is Pulled Backward toward the Heavily Loaded Bed on the Ground. When a Point Is Reached where the Rear of the Chassis Is Approximately over the Front of the Loaded Bed, the Portacana Stops Moving. The Loaded Bed Begins To Rise, Front End First, until It Touches and Is Pulled over a Large Roller at the Rear of the Chassis

The Portacana marks a definite step forward in the removable-body field. While it was developed primarily to haul sugar-cane, the possibility of applying it to other fields was always borne in mind. Its possibilities in other industries will be apparent as its operation is observed. It, as the name indicates, is a motor-driven vehicle specially designed to load, haul and unload sugar-cane in the quickest time and in the most economical way. It consists of a 5-ton-truck chassis equipped with a removable bed and a special loading mechanism. The bed is released from the chassis over a series of rollers and, when loaded, is drawn back over the rollers onto the chassis by a cable that operates from a winch geared to the truck engine. By using a number of the removable beds with a single vehicle of this type, cane can be transported from field to railroad at the same time the beds are being filled by the workers in the field. It was first tested in Cuba, where the slow and cumbersome ox-cart is still being used.

On the majority of Cuban plantations, sugar-cane is cut by hand. After being cut, it is thrown into piles and each pile is the center of an area of uniform diameter, determined by the distance the cutters can throw the cane. The amount of cane in each pile depends upon the density of growth and varies from $2\frac{1}{2}$ to 6 tons. It has been the practice to carry cane from the field to the railroad by ox-cart but, with this new method, the ve-

Fig. 6—The Loaded Portacana Ready To Move
When the Pull of the Cable on the Front End of the Bed Balances the Hanging Load at the Other End, the Bed Drops Gradually into a Horizontal Position on the Chassis, Resting on Both the Rear and the Middle Rollers, the Latter Being Clearly Shown in Fig. 5. The Bed Is then Pulled Forward until the Front End Reaches the Front End of the Load Space on the Portacana, Where an Automatic Stop Mechanism Throws the Winch Out of Gear and Locks the Bed Firmly in Position. The Total Time Required for the Loading Operation Is Not Over 1 Min.

hicle shown in Figs. 4 to 6 comes into the field with an empty bed, which is released beside one of the large cane-piles. The Portacana is constructed so that the bed, upon release and a push backward by the driver, tilts up at the front and slides to the ground over rollers mounted on the truck chassis. When the truck moves away, the front of the bed drops. The bed is then left flat on the ground ready for loading either by the cane-cutters themselves or by a special loading-crew.

The truck then moves to another point in the field, where a bed previously dropped has been loaded with cane, as shown in Fig. 4. The operator backs the vehicle up to within 15 or 20 ft. of the loaded bed, and the cable leading from the winch is fastened to the hook on the front of the bed. The winch draws the cable taut, and the truck is pulled backward toward the heavy, loaded bed on the ground, its brakes being released during this operation. After having been pulled backward to a point where the rear of the chassis is approximately over the front of the loaded bed, the truck stops moving and the loaded bed begins to rise, front end first, until it touches and is pulled over the large roller at the rear of the vehicle; a loaded bed in this position is illustrated in Fig. 5. Reaching the spot where the pull of the cable on the front end of the bed balances the hanging load at the other end, the bed drops gradually into a horizontal position on the chassis, resting on both the rear and the middle rollers. It is then pulled forward until the front end reaches the front end of the load space on the chassis, where an automatic stop mechanism throws the winch out of gear and locks the bed firmly in position, as shown in Fig. 6. The entire time consumed in this loading operation is not more than 1 min. This is a decided contrast to the ox-cart method, in which the vehicle must wait while two or more men throw the whole load of cane from the ground into the cart, the oxen meanwhile being turned out to graze.

Unloading at the Railroad Station

With the bed locked in position, so that it cannot tip sideways or roll either forward or back, the vehicle is driven off the field to the grua or loading station at the railroad siding. The grua is a high frame-work of sufficient span to cover the railroad siding, the roadway and the weighing scales.

Suspended from the over-arching frame of the grua is a sub-frame carrying about five pairs of pendant chains. The load is lifted from the truck bed by the power mechanism of the grua and shifted over to a position directly above the waiting railroad car. At this point, a quick-acting tripping-device releases the load of cane into the car.

Efficiency of This Method

As soon as the load of cane has been lifted clear of the bed, the truck is ready to be driven back to the field. The time required for weighing the load and removing it from the vehicle is not more than 3 or 4 min. It is customary to employ from 10 to 20 removable beds with one vehicle, the empty beds being filled one by one while the truck is hauling the loaded beds to the railroad. Hence, it will be seen, a single such vehicle will haul the whole output of a large crew of cane-cutters. Moreover, in case of fire, when the scorched crop of cane must be removed within 2 or 3 days to be marketable, this vehicle is invaluable as a hauling unit. It can be worked 24 hr. per day, requires no fodder for upkeep and is much faster and more reliable than the ox-drawn vehicle. A single truck of this kind, with a group of beds, will do all that can be accomplished with a dozen ox-carts, and more efficiently, more rapidly, at less than half the cost and with greater reliability.

Aside from cane-hauling, the Portacana offers great possibilities in the transport of many types of farm produce. Fruit growers, truck farmers and ranch owners find of practical value the ease with which it can be loaded, as well as the saving in time made possible by the use of removable beds. In transporting merchandise from railroad to store, or from factory to railroad, the method offers great possibilities for further development work. Its removable body, or bed, can be picked up from any place. A loading dock with tracks and other special equipment is not needed. All the necessary equipment is on the truck itself. Surely this is a step forward in the development of a practical removable body or container.

AMERICAN AGRICULTURE

AMERICAN agriculture began a new era in 1900. We had come to the end of the unprecedented expansion that characterized the 30 years from 1870 to the end of the century. More than 3,000,000 new farms were settled during those three decades. In each decade we had added a small empire to our agricultural territory. Even in the 10 years between 1890 and 1900 we settled more than 1,100,000 of these. After the beginning of this century the increase continued but at a slower rate. By 1910 we had added another 624,000 farms. But this addition was no more than sufficient to keep pace with the growth of our own population. No longer did the growth in American production outrun the growth in American consumption. It began to lag behind, and the export surplus steadily declined. This, coupled with the general rise in the price level, was the principal reason for the increase in agricultural prosperity. The gross value of all farm products, excluding crops fed to live stock, had stood at $2,904,000,000 in 1897; by 1900 it amounted to $3,549,000,000; in 1910 it amounted to $6,607,000,000. Despite the fact that the price of the things which the farmer purchases rose, the total purchasing power of all people engaged in agriculture had increased 70 per cent during these 13 years. The per capita purchasing power had risen 40 per cent. It is interesting to note that while the value of products of the farms of this Country rose 22 per cent in the 3 years between 1897 and 1900, from 1921 to 1923, or only 2 years, the increase was greater, being 23 per cent.

Today farms are fewer and fewer persons are engaged in farming than was the case 14 years ago. But our urban population has continued to grow rapidly since the beginning of this century. As against 45,000,000 people living in towns in 1900, and 60,000,000 in 1919, today 80,000,000 reside in towns. By 1930, in all likelihood, 90,000,000 persons will be in cities and towns to be fed by the farmers of this Nation. —*David Friday*.

Discussion of Papers at 1924 Semi-Annual Meeting

THE discussion at the Crankcase-Oil Dilution and the Transmission Sessions of the recent Semi-Annual Meeting was constituted chiefly of questions written upon question cards and read to the various authors by the chairmen. In addition, some oral discussion was offered from the floor and several written discussions were either read at the meeting or submitted subsequently. In every case copies of the stenographic report have been submitted to the various speakers and the authors for correction and, in the case of the latter, for additional comments. Where these have been received, they have been included in the discussion.

A brief abstract of each paper precedes the discussion for the convenience of those members who wish to refresh their minds as to the points covered without it being necessary for them to refer to the complete text. Those of the members who wish to look over the illustrations that appeared in connection with the papers as originally published, or to read the complete text of these papers, will find all of them printed in the July issue of THE JOURNAL.

WATER IN CRANKCASE OILS

BY A. LUDLOW CLAYDEN[1]

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

DESCRIBING the three ways in which water may reach the oil-pan, the author says that the danger-point for water accumulation is reached where an emulsion becomes too highly viscous or when an accumulation of free water reaches the pump intake. The effect of using an emulsifying oil is explained and consideration is given the amounts of water actually deposited because of cylinder-wall condensation. An emulsion of oil with water up to 5 or 6 per cent differs hardly at all from the pure oil so far as film-forming and lubricating qualities are concerned. On the other hand, with an oil that is absolutely non-emulsifying, the tendency is for the water to segregate and collect in comparatively large globules. The ability of an oil to absorb a small percentage of water has the advantages of minimizing the danger of complete failure of oil circulation when starting in cold weather, and of reducing somewhat the rate of piston-ring and cylinder-wall wear.

Experimental work that enables the rate of deposition of water to be determined was done by the company the author represents, a special engine being constructed for this purpose. Illustrations of the engine and the testing apparatus are presented and a description is included. The work has been continued for many months. Numerous check-runs have indicated that the rate at which water appears in the cylinder oil is shown by a straight-line graph between 35 and 110 deg. fahr., the deposition ceasing at the latter temperature. When continued below 35 deg. fahr. in the same straight line, the graph shows that at 0 deg. fahr. the rate of deposition would be 80 cc. per hr.

THE DISCUSSION

F. E. MOSKOVICS:—Various controllable factors in an engine undoubtedly affect the rate of dilution and consumption of the lubricant. The amount of the dilution can, however, be reduced to the minimum without redesigning the engine. Various oils of different viscosities respond differently to dilution, but with all of them dilution does not increase beyond a certain point. At least, this is true of a given oil in an engine. As the oil thins out, the engine temperature rises until evaporation offsets the dilution and a point of equilibrium is reached. This diluted oil, if uncontaminated, may still serve as a lubricant. But the thinned-out film between piston, piston-rings and cylinder-walls does not provide as good a seal as the original oil. The natural result is increasing contamination as the combustion-chamber is the point of origin for the bulk of contaminating matter.

With mineral oil, the oil-film on the cylinder-walls above the piston on the intake stroke, because of its affinity for gasoline, is diluted, partially vaporized and to a certain extent becomes a part of the fuel itself. The oil thus vaporized and mixed with the gasoline reduces the ignition point and also increases the end-point of the compressed fuel, so that only the more-volatile portion of this mixture is burned in the combustion-chamber, the remaining portion being subject to destructive distillation. With the small amount of oil left on the cylinder-walls, only a partial seal is provided and the heavy unconsumed fractions pass the piston-rings and find their way into the crankcase, carrying with them impurities introduced with the gasoline. As dilution increases, the film on the cylinder-wall is more easily absorbed with an ever-increasing resultant contamination.

Castor oil blended with a highly refined mineral oil reduces the crankcase dilution and therefore the contamination to the minimum. It has great adhesive properties for hot metal and, because of its repelling characteristic for hydrocarbons, tends to prevent the gasoline from absorbing the film of oil on the cylinder-walls, thus correcting the most prolific cause of crankcase dilution as well as reducing the principal cause of contamination. With castor oil the carbon produced in the combustion-chamber is soft and easily expelled through the exhaust port.

Recently a 1-hr. test-run was made, using a blend of castor oil and mineral oil as a lubricant, in the traffic of the Metropolitan district. The car was a stock open car and was supplied with 6 qt. of the oil blend. Although the car was stopped numerous times because of traffic, the engine was run continuously throughout the

[1] M.S.A.E.—Chief engineer of gas-engine research, Sun Oil Co., Philadelphia.

test period. After the run had been completed, the oil was removed from the car and measured. The oil was slightly warm, having a temperature of approximately 85 or 90 deg. fahr., and appeared to have retained its original viscosity, being noticeably free from dilution with gasoline. Laboratory analyses of this oil, both as supplied to the car and as drawn off upon the completion of the test, are given in the accompanying table.

	Original Oil	Used Oil
Specific Gravity at 15.5 deg. cent. (60 deg. fahr.)	0.896	0.895
Flash-Point, deg. fahr.	448	216
Fire-Point, deg. fahr.	476	398
Cold-Test, deg. fahr.	21	23
Viscosity at 100 deg. fahr., sec.	593	425
Viscosity at 210 deg. fahr., sec.	76	67
Light-Oil Dilution, per cent	...	2.5
Contamination, Such as Carbon, per cent	...	0.005
Free Acid, per cent	0.12	0.120

A. L. CLAYDEN:—I did not take part in the discussion of Mr. MacCoull's paper, but I take this opportunity of saying that I agree entirely with practically everything that he has noted. I have not covered nearly the same amount of ground in the same way that he has, but in every case in which I have done that kind of work, it has checked exactly with his deductions; and the importance of the crankcase temperature and of the degree of agitation to which the oil is subjected, which means the quantity pumped and the size of the orifices through which it is pumped, is undoubtedly very great.

QUESTION:—Does the "loss" side of the line represent what was originally in the oil before it was used?

MR. CLAYDEN:—Fig. 3 represents the rate in ounces per hour at which water appears in the oil in an average engine. The actual figures are simply deduced from the results obtained from the experimental engine. In this way they represent the loss of water from the oil that contained it.

When an engine is started, the oil begins to accumulate water, until it gets to 110 deg. fahr.; from that point the accumulation of water ceases.

As the water-jacket temperature goes above 110 deg. fahr. and continues to increase, the water begins to dry out of the oil. The temperatures are water-jacket temperatures. In this case, the cylinder-wall was very thin; it was perfectly cylindrical, and machined throughout. It had a thin copper water-jacket. I believe that the temperature of the inner cylinder-wall is very little above the observed temperature of the water in the jacket.

QUESTION:—How much water is formed from the complete combustion of 1 gal. of gasoline?

MR. CLAYDEN:—In volume, approximately 1½ gal.; in an ordinary combustion-engine running in the ordinary way, about 1 gal. I believe the recovery in the engines of the Shenandoah has been about 1.4 gal.

DR. H. C. DICKINSON:—That is nearly correct. The amount of water is about 25 per cent greater by weight than the amount of fuel. It is not easy to recover more water than the weight of the fuel.

QUESTION:—Was a study made of the effect of atmospheric humidity on water dilution? Was the humidity constant in producing the straight-line curve in Fig. 3?

MR. CLAYDEN:—No; because the straight line represents the average of tests conducted under all kinds of weather conditions for about 1 year. I should have said that that straight line does not represent an average of what F. W. Lanchester used to call a "shot-gun diagram." The observed points were never more than a very little off the line.

QUESTION:—What were the room-temperature and the humidity at the time the tests were run?

MR. CLAYDEN:—They varied in every conceivable way, but there never was any traceable connection between them. We tried to operate the engine, keeping its own temperature, the oil temperature, and so forth, constant. The humidity had no effect, and the nature of the fuel had very little effect. We ran steadily on the same fuel in getting the results that were plotted in that curve, but only far enough to be very sure. It would not have made much difference if we had used half a dozen different grades of fuel.

QUESTION:—Is water from the gasoline used, or does part of it come from the air?

MR. CLAYDEN:—I do not think that condensation from the air occurs. I believe that it is purely a condensation on the cold cylinder-wall, exactly like the condensation on a window pane when you breathe against it, and that, the temperature of the burning gas being more or less constant, at least so far as its center is concerned, the amount of water deposited out of it in constant time, which is the duration of the piston stroke, will be more or less inversely proportional to the temperature of the surface against which the gas impinges.

Why the crossing-point should come at 110 deg. fahr. is a mystery. I expected it to be considerably higher. I have been able to make only very rough estimates of what the interior temperature of the wall is, but it certainly is not 100 deg. higher than that of the outside, and one would expect the deposition of water to cease very much nearer the boiling-point than 100 deg. fahr.

R. E. WILSON:—I think we can answer the questions regarding the relative amounts of moisture that come from the air and from the gasoline by pointing out that the intake air, if saturated at 70 deg. fahr., would carry less than 2 per cent by weight, whereas the products of combustion of a 12 to 1 mixture of gasoline would carry approximately 10 per cent by weight. Since the air would probably not be much more than one-half saturated, we may say roughly that 10 times as much water is in the burned gases as was brought in with the air, and therefore ordinary variations in the humidity of the air have a negligible effect.

As to the reason for this 100-deg. temperature-difference between the boiling-point of water and its apparent condensing point in the cylinder, we must remember that the 110-deg. cooling-water temperature at the critical point does not represent the temperature of the oil-film or even of the inside of the cylinder-wall, and it is this temperature of the surface of the oil-film which determines whether condensation or evaporation takes place. Since there is a temperature-drop between the oil-film and the cylinder-wall, and another between the cylinder-wall and the cooling water, it seems to me quite conceivable that the oil-film might be 40 or 50 deg. hotter than the water.

Another equally important fact is that you are not condensing pure steam. You have a mixture of steam with a large amount of inert gas, and the condensing temperature, therefore, is not 212, but probably below 150 deg. fahr.

QUESTION:—If the cylinder-jacket temperature is maintained above 110 deg. fahr., will the water be eliminated entirely?

MR. CLAYDEN:—Yes, after a sufficient period of running. The rate of loss at a little above 110 deg. fahr. is very slow. As you go more and more above 110 deg.

fahr. the rate of loss increases. The process reverses itself almost perfectly.

A MEMBER:—Judging from our experience, it takes a temperature of 240 deg. fahr. to remove water from the oil-pan and it is not possible to get enough heat from any source on the oil-pan to evaporate the water. The high temperature that is necessary is due, no doubt, to the fact that the water and the oil are in the form of an emulsion.

R. W. A. BREWER:—In the absence of agitation, 240 deg. fahr. would be a reasonable temperature but, with agitation, it is an entirely different matter.

MR. CLAYDEN:—The loss-of-water observations were checked by dynamometer runs with an ordinary engine, and the results obtained in that way agreed very well. Agitation is a very important factor. In the engine that we used, which was the Oakland engine that we used for checking, the amount of agitation was, I think, a little above normal.

H. E. A. RAABE:—The working-piston, as I understand it, was connected to the piston working next to the crankcase by what might be called a piston-rod, so that no side-strain was placed upon the piston. It was not subjected to any side-slap, which is a serious factor in an engine that has had some wear. Inasmuch as the piston working next to the crankcase was not subjected to the same conditions as was the working piston on the suction and the compression strokes, I do not believe that data taken under such conditions are of any value as to the results of oil contamination.

MR. CLAYDEN:—The upper or working piston is operating in an engine of this kind under ideal conditions, and any water contamination that you will be able to observe will be much less than you would be likely to find in practice. Therefore, you can be very safe in taking the results obtained from these tests as being the minimum results and not the maximum. Although it is almost impossible to operate an ordinary engine long at a low temperature like 35 deg. fahr. without a much larger refrigerating plant than the one I possessed, rough checkwork on ordinary engines shows that the condition with an engine of ordinary construction is considerably worse than that we obtained experimentally.

QUESTION:—In eliminating water or diluent would it be effective to heat the oil stream, either before it entered the oil-pump or before it returned to the oil reservoir? This, it seems, would entail less difficulty than heating the entire crankcase.

MR. CLAYDEN:—The oil must be hot at the time it is injected into the bearings. That is where the heat is needed.

NEIL MACCOULL:—We made an experiment in which we controlled the temperature of the oil by running it through a cooler before it went to the bearings. To our surprise, we found that the temperature of the oil had very little to do with the crankcase temperature. The heat-carrying capacity of the oil was apparently so much less than that of the webs and the walls of the crankcase that we could not heat the air into which the oil sprayed by regulating the oil temperature alone. The evaporation of either the diluent or the water from the oil is far more dependent upon the temperature of the air in the crankcase than upon the temperature of the oil itself.

DR. DICKINSON:—Mr. Clayden's paper is a beautiful illustration of the way some engineering observations check up with the elementary theory that most of us, perhaps, have forgotten. Another phase of it that interested me particularly is that the same elementary theory is applicable to the oil-dilution problem in fuel in exactly the same way as to the formation of water.

At the risk of talking about things that are too elementary, I would like to outline just what sort of action takes place. Suppose that you have a cylinder containing a mixture of vapors. According to Dalton's law, the amount of any one vapor that can be present without condensing is independent of what other vapors are present, if one does not affect the other. Whether air is present to the extent of 0.1 or 2.0 atmospheres pressure does not make any difference in the amount of water vapor that can be present in the same space.

In the case of the mixture of gases resulting from combustion in the cylinder, the amount of water vapor present is such that at a temperature above approximately 120 deg. fahr., no condensation will occur. That figure was worked out roughly in connection with the development of a method for recovering water from the exhaust gases of airship engines to maintain the total weight constant as the fuel is burned. I think the average is about 50 deg. cent. (120 deg. fahr.).

You all have noted that, when you set a pitcher of ice water on a table in hot weather and let it stand for a while, you are likely to have an area at the bottom of the pitcher that is wet, and at the top an area that is dry. The difference between those two portions of the pitcher is only 1 or 2 deg., but one of them condenses water because it is below the dew-point, and the other portion evaporates water because it is above the dew-point.

The cylinder-wall, as has been suggested, is probably somewhat warmer than the jacket-water. If this figure of 110 for the jacket-water at which condensation begins on the cylinder-wall is exact, it is possible to tell how much hotter the cylinder-wall actually is. The temperature of the cylinder-wall will be exactly the temperature at which condensation will cease or in other words the dew-point temperature of the gases in the cylinder. This temperature is probably about 120 deg. fahr., if the mixture-ratio were accurately known, this temperature could be determined very closely, whereas the jacket-water temperature is about 110. It is perfectly definite that this must be the temperature of the cylinder-walls at which water begins to appear in the oil, for, at any temperature above that point, no water will condense and, at any temperature below that point, water will condense. It is to be expected that the amount of water will be nearly proportional to the difference between the dew-point temperature and that of the cylinder-walls.

Of course, the fact that water is in solution in an oil-film may possibly change the condensation temperature slightly, but not very much, probably not more than from 2 to 3 deg. at the most, because there is no appreciable chemical action between the oil and the water, and the solution that takes place does not affect the equilibrium very much.

It seems to me, then, that, so far as the water is concerned, the cylinder-wall temperature is a very definite thing and that the measurements described by Mr. Clayden might serve as a method for actually determining the cylinder-wall oil-film temperature on an average.

I think that this little engine of Mr. Clayden's is better adapted to a fundamental study of the phenomena of crankcase-oil dilution, as affected by condensation on the cylinder-walls, than anything else that we have had presented. Of course, a complex mixture like fuel does not act like water, because it does not have the same sort of definite vapor-tension and condensation-temperature, but Mr. Wilson has shown that, when the fuel is in the

presence of its own vapor, it reaches a point at which it acts effectively as a single substance, that is, the equilibrium mixture that can be produced by Mr. Wilson's method acts as if it were a single substance so long as it is subjected to the vapor of the entire fuel.

Now, suppose that this cylinder is filled with vaporized fuel. If equilibrium can be reached, a thin film of the equilibrium mixture of fuel will be found on the wall. That corresponds very closely to what has been found with regard to the diluent in the crankcase oil. If the temperature of the wall is above the temperature at which this equilibrium mixture will evaporate at the given concentration of the mixture, the fuel will evaporate from the cylinder-wall. If the temperature is lower than that, a similar amount of fuel will condense on the cylinder-wall; and the temperature at which this will occur, of course, will depend on the composition of the fuel, that is, what the equilibrium mixture happens to be, and the mixture-ratio.

The amount of condensation and also the dew-point temperature will depend on the concentration because in a leaner mixture the vapor-density of the fuel is less and the condensation-temperature is lower. If it is a 15 to 1 mixture, the vapor-density will be less than if it were a 12 to 1 mixture, and the condensation-temperature will be correspondingly different in the two cases.

I suggest that, if Mr. Clayden find it possible, he try to see whether the application of the same ideas will check equally well in trials in this same engine with fuels of different equilibrium-compositions. I am inclined to predict that the results will show the same sort of concordance with elementary theory that they show in the case of water.

W. L. DEMPSEY:—What force impels the water through the space between the cylinder-walls and the piston? Also, what is the magnitude of that force compared with the force that is used to drive oil into the bearings of the engine?

MR. CLAYDEN:—It is moved mechanically. I do not think the two things are at all analogous.

MR. BREWER:—It may be interesting to know that we have found the water-content in crankcase oil to amount in some instances to as much as to 34 per cent. That is about the highest observation that we have made. The samples that come through in the wintertime generally are about 5 per cent, sometimes about 2 per cent; 34 per cent was taken from a Ford not long ago.

I gathered from the very interesting data which Mr. Moskovics ran over quickly that he was giving us the results of some tests with what appeared to me to be a very viscous oil. I believe that he said 593 sec. at 100 deg. fahr. and 76 sec. at 210 deg. fahr. It seems to me that, if we match that with what Mr. MacCoull told us in his paper and showed us in the curves, and with the general experimental work with oils of various viscosities, our object now is to use an oil having as low a viscosity as possible under working conditions, because the amount of power lost through friction varies with the viscosity of the oil, as, under the ordinary working conditions of an engine, at least 50 per cent of the power developed, and in some instances very much more than that, is consumed in shearing the oil-film; and the shearing of oil-films of various viscosities means a loss of several horsepower.

I think there is no question on that point. But what is interesting is this: If we can use a thin oil-film and we take advantage of adding some free fatty acids to the oil, which, I take it, is the object of this suggestion regarding the use of castor oil, we obtain the "safety factor" that we want in using a thin or a less viscous oil. Judging from the report read by Mr. Moskovics, the intent appears to be very good indeed, but the method of applying the castor oil to an ordinary lubricating oil was at fault, because it formed a composition that was too viscous.

I would like to say further that the conclusions drawn from the report are not based on anything but conjecture or opinion, and that, if we had a comparative set of figures, or something at all comparable with those obtained from the same engine under ordinary conditions, we should be much better able to valuate the advantage of mixing castor oil with mineral oil.

B. B. BACHMAN:—The problem of oil contamination has come to the front within recent years and seems to be more or less concurrent with the change in the characteristics of the fuel used. In the early days of automobile history we had a volatile fuel that acted very differently from that which we are using now, and for that reason the matter of the dilution of the oil by portions of the fuel was less in evidence. The viscosity of the oil probably maintained a closer uniformity than it does under present conditions. The highways at that time were not paved but, although traffic was not so dense, I think we all have unpleasant recollections of driving through dense clouds of dust. It seems that the breathing of this air by the engine would carry at least as large a volume of dirt into the combustion space as we have under the average operating-conditions of today with better kinds of pavement, even with the higher traffic-density under which we are operating.

Possibly one popular way of assessing that difference is the relative disappearance of the use of goggles. Of course, that may be compensated for by the type of glasses that we wear at the present day. It seems to me, however, that a relation exists between those two things, the greater amount of dirt we had in those days as compared with what we have today, and the difference in the viscosity of the oil under operating conditions.

The further contamination of lubricating oil by water is another condition that is not nearly so clear. From some work that has been published, I can understand that the water in the oil, being acted upon by certain products of combustion and forming acids that are detrimental, is a real danger. We have had evidence of that, but it seems to me that there again the variable has been a matter of the variation of the fuel.

The amount of water that will be deposited by combustion is the same today as it was 20 years ago; the cylinder-wall temperatures are much the same today as they were 20 years ago. It may be that the average temperatures are a little higher today, generally speaking, than they were at that time, because of a more general use of thermostats and devices of that character to keep the operating temperatures higher, originally for the purpose of facilitating vaporization and combustion.

I think the ingenuity that Mr. Clayden has used in developing his apparatus is commendable. I am rather disappointed that the paper did not contain a larger amount of data. It impressed me as more or less of a resume of the work, not giving in detail information that seems to be highly desirable.

Has Mr. Clayden done anything that connects the question of engine load-factor with the deposition of water? The figure that he showed us gave two variables, temperature and water deposition. It seems to me that, if we could hold one of these temperatures constant, and have as variables the deposition of water and the variation of load factor or throttle-opening, that might give

us some additional information that would be worth-while.

With regard to the question of water appearing in the oil, I have had samples similar to those Mr. Brewer mentioned, containing from 30 to 40 per cent of water. It is difficult for me to see where that amount of water comes from, unless some one took hold of the wrong spigot in filling the crankcase. But I have collected a few figures from my notebook on this question. In March, 1923, I had six of the trucks that were in our service followed up. These vehicles were kept in heated garages. I mention that fact for the reason that I believe that some of the water that we find in the oil in the crankcase may result from the condensing of the air inside the crankcase as it becomes chilled in a garage. Objection will probably be made to that suggestion, because, as Mr. Wilson has outlined, the percentage of water in the atmosphere is not very important. But I hold that opinion; if it is wrong, I am willing to be criticized for it.

I took these trucks at random. They had not been drained for some time or with any particular system, and five of the six were operating in long-distance hauling, making runs of from 100 to 150 miles at a time. The sixth vehicle was operated from our plant in Philadelphia more or less as a hack, and an observer sitting with the driver of the truck found that he would keep the engine going as long as 45 min. after the vehicle had stopped. The results of the first examination showed that on the trucks that were used in long-distance operation the dilution was from 15 to 20 per cent. The method that we used was, of course, our own. I do not know that it can be compared with anyone else's, but I will give you the figures as qualitative rather than quantitative. The other vehicle, operating in intermittent service, showed 35 per cent. Only two trucks showed the presence of water. One of the long-distance vehicles had 0.10 per cent, the other 0.03 per cent.

I drained the crankcases at the end of various periods and found that in 2 weeks' time the dilution on the five long-distance trucks ranged from 10 to 15 per cent, and that on the vehicle used in intermittent service the dilution was 25 instead of 35 per cent. At that time very small amounts of water, differing from those of the first test, were present in two of the trucks.

After a few tests of this sort, the conditions were about the same; I kept the worst vehicle and began experimenting with it. I made some minor changes in piston construction, in manifolding and the like, and finally put on a starting-motor with orders to the driver to stop the engine whenever he stopped the truck. I kept a record of that vehicle, draining the crankcase monthly. The truck made an average of 350 miles per week, or about 1400 miles per month; so, in a year, it has run about 16,000 miles. The results, beginning in June, 1923, are given in the accompanying table.

RESULTS OF DILUTION TEST

Month	Dilution, Per Cent	Water, Per Cent
June, 1923	10	Trace
July	9	0
August	8	0
September	9	0
October	11	0
November	11	0
December	13	Trace
January, 1924	11	Trace
February	21	0
March	13	0
April	14	Trace
May	17	Trace

This month that particular truck is using an oil similar to the one that Mr. Moskovics mentioned, possibly the same oil. I have not the figures from that test as yet because it has not been completed.

MR. WILSON:—Referring to the report read by Mr. Moskovics, I do not wish to go into detail, but, in speaking of the repellant action of castor oil to gasoline, he is likely to give an entirely wrong impression. The fact is that it has an attractive or solvent action like that of any other oil, although not so great as that of mineral oil for gasoline.

I have made and reported some measurements on such materials and found that the solvent action, that is, the amount that castor oil would absorb from a gasoline-air mixture of definite concentration was, as I recall it, between two-thirds and three-fourths as much as that absorbed by ordinary oil. Furthermore, this is for pure castor oil; by the time you were to get a reasonable blend that anyone would wish to use or could afford to use, the difference would be negligible.

The test described is, to my mind, absolutely meaningless, so far as the extent of dilution is concerned, without comparative tests under identical conditions on some other oil. Obviously, running an engine continuously for 100 hr. is not the way to find out what the dilution is likely to amount to, and keeping the engine running while the car is stopped is not the way to secure marked dilution. Dilution would have been much more serious had the engine been allowed to stop and cool off at intervals.

FACTORS AFFECTING THE RATE OF CRANKCASE-OIL DILUTION

BY JOHN O. EISINGER[2]

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

THIS paper deals with progress in the Cooperative Fuel Research since the last report was presented to this Society. Previous tests had shown that the temperature of the jacket water exerted a major influence on the rate of dilution of crankcase oil. The reason for this influence was investigated and it was concluded that it was due to differences in the rate at which diluent was added to or eliminated from the oil-film upon the cylinder walls, the temperature of this film being dependent upon the temperature of the jacket water. Experiments failed to show that changes in the temperature of the piston head or changes in the viscosity of the oil upon the cylinder walls exerted a major influence upon the rate of dilution. These conditions were investigated as being probable consequences of a change in the temperature of the jacket water.

Evidence is presented which demonstrates that under

[2] Assistant mechanical engineer, Bureau of Standards, City of Washington.

certain conditions the diluent may be eliminated from the oil at a fairly rapid rate. The bearing that this has upon the possibility of an equilibrium state being reached is discussed. Considerable miscellaneous information is presented which relates to the manner in which dilution takes place and the influence of various conditions upon its rate.

APPENDIX

TRANSITION METHOD FOR MEASURING CRANKCASE-OIL DILUTION[3]

The percentage of diluent in the used oils is determined by a distillation method as follows: A 100-cc. sample of the diluted oil is distilled from an electrically-heated Engler distillation-flash of 250-cc. capacity. The flask is well insulated externally up to the vapor tubes, the rate of energy input being such as to give a distillation rate of about 1½ cc. per min.

The thermometer, of the American Society for Testing Materials high-range distillation type, is mounted as for standard fuel-distillation. Vapor temperatures corresponding to each cubic centimeter of distillate are taken. The distillation is carried on with constant heat-supply until the distillate obviously becomes lubricating oil and until the vapor temperature corresponding to each unit-volume of distillate shows a slow uniform rate of increase, 2 to 4 deg. cent. (3.6 to 7.2 deg. fahr.) per cc.

The data so obtained are plotted as a distillation curve, and straight lines are drawn on the oil curve through the region of uniform rise in temperature and through the region of greatest temperature immediately preceding it. The volume of distillate corresponding to the intersection of these lines is taken as the percentage of diluent.

This method gives good results when checked with prepared samples of known dilution and more consistent results than the previously used method of distilling up to some arbitrary temperature and correcting for the distillate from the unused oil at the same temperature.

This transition method works well with oils having only a small amount of light ends but should be used with caution on oils having an appreciable fraction coming off below 300 deg. cent. (572 deg. fahr.). As yet the method has not been sufficiently studied and standardized to justify its recommendation for general use.

THE DISCUSSION

CHAIRMAN R. E. WILSON:—The extreme importance of maintaining a reasonably high temperature of the oil on the cylinder-wall is apparent, in view of the fact that by so controlling the temperature, the dilution and the water condensation can both be greatly reduced.

F. S. DUESENBERG:—I think that the supercharger will be one of the factors in the future for reducing the dilution of crankcase oil. We were very much surprised, when we began experimenting with the supercharger, to find what it actually would do in the way of giving good carburetion and how we could place any kind of intake-pipe on the engine and get equal burning of the fuel in all the cylinders.

After the race was over at Indianapolis, we dismantled the engine and inspected the exhaust-valves. Very much to my surprise, six of the eight exhaust-valves were as bright as if they had been intake-valves; only two of them were black. We do not know whether that is owing to ethyl fuel or to the perfect mixing we got with the turbo wheel. The supercharger wheel had a diameter of 6½ in.; it turned at about 18,000 r.p.m. during the race. We believe that the gasoline in use at present can be handled, carbureted and made into a perfect gas even though you may have to use an intake pipe that is from 15 to 20 ft. long. You can burn the fuel just as well as we do now with a short one.

QUESTION:—How many tests do the curves for the one-ring test represent? Was more than one test made for each condition?

J. O. EISINGER:—We made several tests with one ring on the *A* engine also; the result was substantially the same as on the *B* engine.

NEIL MACCOULL:—As I went over Mr. Eisinger's paper, it seemed to me that there was nothing I could add to it. I was very much pleased to find that, while I had known nothing about his work in detail before and during the time we were planning our own work, yet he covered very similar ground, and his conclusions, in general, are practically the same as ours. I think that is an excellent check on the type of work that we all are doing.

PRESIDENT H. M. CRANE:—It looks to me as if we were getting a pretty fine set of tools to work with on this subject, and that in the future there will not be nearly so much chance for quack remedies as there has been in the past.

I think the most interesting thing brought out in the last paper was the fact that oil dilution is not affected much by piston-ring and piston design. It will also help those of us who have tried to come into contact with the oil people to ask for things that we are justified in asking and not for fool things that we ought to take care of ourselves.

Tomorrow, when we get through with the papers on air-cleaners, we shall have a pretty fair picture of the whole problem. However, I have noticed among the oil people a tremendous and not wholly remarkable enthusiasm for the frequent draining of the crankcase. I have read on Long Island, in letters a foot high, that draining is essential after every 500 miles, at all times of the year. That may be a good thing in the case of certain cars, but I have been told by an oil man that some thrifty garagemen in the Middle West sell the drained oil to the next fellow that comes along to put into his crankcase.

W. L. DEMPSEY:—About 15 years ago, when we were building large tractors, I drove one at the rate of 2 m.p.h., corresponding to an engine speed of 300 r.p.m. The powerplant consisted of a single-cylinder engine having a bore of 12 in. and a stroke of 16 in., and an automatic intake-valve. By adjusting the valve and admitting pure air into the cylinder, I succeeded in producing a major and a minor explosion as regularly as pulse-beats on the ordinary working stroke. Now, as I understand this bomb, by adding additional air, you get an indefinite number of explosions with one charge of fuel.

MR. EISINGER:—Yes.

MR. DEMPSEY:—So, after 15 years, I am very gratified to find my conclusions were correct, that is, to burn completely the fuel taken into a gas engine on the induction stroke, it is absolutely necessary that a surplus of air be present. Mr. Duesenberg says that when supercharging the cylinder, to his surprise or to his gratification, he found no carbon on the exhaust-valves, that they were clean. It seems to me that this problem can be reduced in the final analysis to one thing, a surplus of air, that is, more air than is theoretically necessary. That is why I asked the question about the exact amount of water that should result from the burning of a definite amount of fuel. I thought it would bring out in the discussion the exact amount of air necessary to produce the

[3] Developed by M. E. Preble and T. S. Sligh, Jr., of the Bureau of Standards staff.

water obtained, or in other words complete combustion of the hydrogen element of the fuel, and this would have opened the way for a discussion of the amount of air necessary to combine with all of the fuel taken in at each induction. I am a strong advocate of burning the charge in an excess of air. If this can be successfully done, carbon deposits could not occur, and crankcase-oil dilution would be reduced, if not entirely prevented.

O. C. BERRY:—The importance of cylinder-wall temperature in determining crankcase-oil dilution has been pointed out, I believe, by all the papers presented today. I am inclined, therefore, to ask whether any of the gentlemen presenting these papers has formed an opinion whether a first-class thermostat, governing the jacket-water temperature of the engine, would in the long run be found to be a satisfactory means of eliminating any objectionable amount of crankcase-oil dilution.

MR. EISINGER:—We have not done any definite work along that line but, personally, I should think it would have a marked influence on decreasing crankcase-oil dilution. I would recommend putting thermostats on most cars.

MR. BERRY:—From the view of the picture as you have it now, do you think that a first-class thermostat will keep the oil dilution down enough in the wintertime so that it would not be very objectionable?

MR. EISINGER:—I should judge so. I should think that the thermostat would hold the temperature constant. We keep the water temperature at about 150 deg. fahr., which is not very high, and we get about 5-per cent dilution in 5 hr. operation, which is an extremely small amount.

CHAIRMAN WILSON:—Undoubtedly, results have shown that crankcase-oil dilution can be reduced by getting higher intake-temperatures, better hot-spotting and better vaporization of the fuel. I wonder just how that fits into this picture which indicates that absorption by the cold oil-film is the controlling factor; has the heating of the air automatically raised the jacket-water temperatures in a short period of operation, or has it raised the surface temperature of the film? Or is the impinging of liquid drops of fuel on the wall worse than the mere absorption of vapors by the oil-film?

DR. H. C. DICKINSON:—I think that it is pretty generally accepted, from the results, that the intake-air temperature does not very materially affect crankcase-oil dilution. I am inclined to think that, for the most part, the oil-film on the cylinder-walls is so thin and in so good contact with the metal surface of the cylinder that it is capable of taking up heat as rapidly as the heat is needed, and that the small amount of liquid fuel that strikes the oil-film under ordinary operating conditions is evaporated down to a point that we might term static equilibrium; that is, the oil-film on the cylinder-wall, with its liquid content of fuel, is at all times practically in the same condition that it would be in if it stayed there 5 min. instead of 0.005 sec.

If that is the case, the oil that works down past the piston-rings contains a certain rather definite percentage of diluent at all times, that percentage being determined entirely by the surface temperature of the cylinder-wall. If, therefore, the temperature is raised, the percentage of dilution will decrease, and vice versa.

I would like someone to make experiments with the apparatus that has been shown to us by Mr. Clayden, to determine whether this assumption is measurably true. Mr. Wilson has shown that the fuel which is contained in solution on a cylinder-wall is in the presence of the vapor of the original fuel. If so, it acts in nearly the same way as an equilibrium mixture that vaporizes at some rather definite temperature, depending upon the concentration of the vapor in the fuel space. If we should carry out a series of experiments to test that hypothesis, we might prove definitely whether it is true; and I am inclined to think that it is very likely to be true.

CHAIRMAN WILSON:—In connection with Dr. Dickinson's last remark, I have been interested in noting that wherever the distillation curve of the diluting oil has been measured, its 50-per cent point has been found to be very close to the 85 or the 90-per cent point of the original fuel, which was the generalization that we found regarding the distillation curve of the equilibrium-mixture prepared by the method described a few years ago, in which we, in effect, prepared a large amount of material of the same composition as the first drop that would condense out of a completely vaporized mixture.

I suggest that, in cases in which it is desired to make synthetic dilutions to a definite percentage as often as is desirable in experimental work, this can be done very conveniently and with a close approximation to service conditions by adding to the oil the equilibrium solution prepared in the way previously described for the fuel employed in the tests. This is much more trustworthy than adding either gasoline or kerosene.

C. P. GRIMES:—What effect would piston-head temperature have? I had occasion to run some tests and, placing the piston-head temperature against the temperature of the combustion-chamber as a base-line for comparison, I observed that the head of an iron piston ran approximately 100 deg. hotter than that of an aluminum piston; and I felt that, since you are talking of temperatures of cylinder-walls around 140 or 150 deg. fahr., the temperature of the piston-head next to the rings in contact with the walls should have some little effect upon the temperature of the oil and the condensation of the water that might pass the rings.

One other rather interesting experiment that I made was in applying a thermostat to an air-cooled engine. When working with an air-cooled engine and using a thermostat that was controlled by the temperature of the cylinder-head of the engine, I observed that it took 3 min. for the engine to complete a cycle of temperature range from 400 to 450 deg. fahr. My control was 25 deg. fahr., plus or minus, for the cylinder-head temperature.

If the engine is operating under three-quarter load at normal temperature and at 1500 r.p.m., the combustion-chamber temperature is about 350 deg. fahr. and the surface at the bottom of the piston-ring travel is about 300 deg. fahr. If it really does take 3 min., in this air-cooled engine, for the thermostat to trip off to cool, on to hot and off to cool again, a material length of time has elapsed, and it seems to me that a water-cooled engine, having a large volume of water of high specific-heat, would take a considerably longer period.

The point I want to bring out is that the greater part of the crankcase-oil dilution in a water-cooled engine probably takes place while the engine is warming-up. We made a number of experiments in a cold-box to study oil flow in the crankcase. As has already been said, the thickness of the oil is very important.

I observed that even a fairly good cold-test oil without crankcase dilution required a considerable period of warming-up before the oil would come out of the crankcase in anything but macaroni form, if the temperature were down to 15 deg. below zero fahr. With the minimum amount of summertime dilution, say 5 per cent, the

oil would begin to flow promptly, but would not be thrown off the cranks to lubricate the cylinder-walls until after a 10-min. warming-up period.

What I wish to bring out is that if a new charge of oil were put into the engine, the engine could be started in the cold-box and fired for probably 15 min. before the lubrication on the cylinder-walls would amount to anything. I could not help feeling that during this period the gasoline had not been vaporized, and that the cylinder-walls were cold and washed clean of any lubricant. It makes no difference whether the engine is water-cooled or air-cooled, insofar as the dilution is concerned, because the walls are cold. Combustion will occur as easily with a wall temperature of 20 deg. below zero as at 200 deg. fahr.; and I see no reason why the raw gasoline at compression and the water formed during compression should not go down to the crankcase and be factors in building up the crankcase-oil dilution, regardless of whether a thermostat were used on the cylinders to operate 6 min. after starting or not at all.

T. J. LÍTLE, JR.:—Considerable dilution occurs during the warming-up period; I think we all agree to that. But some experiments that I ran to determine how much dilution we got during that period showed that 15 sec. of intermittent cranking, such as might be required to start a stubborn engine in the wintertime, resulted in driving ½ pt. of gasoline into the crankcase. That sounds like a large quantity of gasoline, but a large volume of gasoline is driven down during the period of starting. Then, during the so-called warming-up period, in the winter, particularly at zero or below, you get considerably more. Hot-spots do not come into play until long after all this gasoline has been driven down into the crankcase. So, it seems to me that we have two problems. Many engines have no hot-spots.

PRESIDENT CRANE:—It seems to me that the thing we do not know anything about is what happens in the cylinder oil-film. We know perfectly well that over a period of time the oil steadily flows up through the cylinder and out through the exhaust-valve. Just how the dilution goes counter to this flow of oil is hard to say. The flow, of course, is intermittent.

CHAIRMAN WILSON:—I have always felt that the action of the piston in carrying a considerable amount of oil between the rings, up and down on every stroke, allowing some of it to go by at the top and some to go by at the bottom, and also picking up fresh oil that has been splashed there while the piston was in the upper part, was an extremely effective mixing device; not very much is mixed on any one stroke, but 1500 r.p.m. will make up for a small amount per stroke.

MR. GRIMES:—I want to tell you about some very interesting cold-box tests that I made with pistons integrally cast with an aluminum head and piston-pin bosses and with a cast-iron skirt. Each metal was cast onto the same sheet-steel strut surrounding the pin-boss.

A normal air-cooled engine was warmed-up for 20 min. by firing in a room temperature of 70 deg. fahr. and allowed to cool for 2 hr. before being placed in a cold-box already chilled to minus 20 deg. fahr. After the engine had been allowed to freeze all night, I found that the room temperature was minus 25 deg. fahr. at the time of beginning this test.

I observed that the engine turned very freely for the first revolution after hard cranking but that it became stiffer with each successive turn. As a matter of record and to remove the personal element I repeated this test on the following day but used an electric dynamometer to measure the torque from the start until the engine became very stiff; at the finish it "squawked."

At the point of "squawking" I made further tests. In one case, after allowing the engine to remain at minus 20 deg. fahr. for 5 hr., I found that the strongest starting-cranks would bend or break before the engine could be turned. In another case, after the engine had been placed in a warm room for 5 hr., I found that I could crank it only with great effort.

In a third case, I removed the engine from the cold-box after it had begun to "squawk," let it remain for about 20 min. while we removed the spark-plugs, then poured about 1 tablespoonful of engine oil at room temperature into each spark-plug hole.

The first three-quarter turn was accomplished only after hard cranking, but after a full turn the engine would spin freely with no effort at all. In fact, it "coasted" for fully a turn after the crank slipped off. The rings of a cold engine undoubtedly retain some oil that lubricates it for not to exceed one revolution.

Gasoline and the water of combustion have easy access to the crankcase when the cylinder-walls and the piston-rings have been scraped clean of lubricating oil; this practically turns to grease when it becomes very cold.

CHAIRMAN WILSON:—Oil can be obtained to meet practically any kind of cold-test. In the market you can get an oil having any desired cold-test.

G. C. BROWN:—Frequent reference has been made to cylinder-wall lubrication. Several years ago, before crankcase-oil dilution became a serious problem, an engine that at the time was very interesting came under my observation; but it seems to be more interesting now than it was then. The engine had been abused by the chauffeur who had been handling the car, and the oil had been allowed to get very low. It was a four-cylinder 4½ x 5-in. engine, the front pair of cylinders being separated from the rear pair, that is, so far as the crankcase was concerned. The crankcase was divided so that the front pair of cylinders was lubricated separately and in removing the cylinders from the engine, it was necessary to use a crowbar to get the rear cylinders off; but the front cylinders came off very easily.

That aroused my curiosity. I found that to quiet the timing-gears, the chauffeur had put in flake graphite, some of which had been ground very fine by the timing-gears and had leaked back into the front compartment, becoming mixed with the lubricating oil and splashed on the cylinders. The cylinders were like the proverbial glass, smooth and bright, with every indication of a perfect fit between the pistons and the rings, no loss of compression being apparent and no wear that could be detected by the measuring devices available.

Today we are using chemicals in the gasoline to get rid of the knock. Is the use of graphite, or something of that kind, indicated also in cylinder oil until such time as these various devices for eliminating crankcase-oil dilution can be perfected?

CHAIRMAN WILSON:—You are probably familiar with Oildag, a suspension of graphite in oil, which has certain advantages and apparently certain disadvantages in carrying solid particles into the combustion-chamber and tending to increase carbon. On the other hand, at least in some cases, there seems to be an effect such as Mr. Brown mentioned.

MR. BROWN:—The two rear pistons were very heavily coated with carbon and had the appearance of having been incandescent when the engine was in operation. The front pistons also had some carbon, with no indication of incandescence.

ENGINE-OIL CONSUMPTION AND DILUTION

BY NEIL MACCOULL[4]

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

AN independent study of a similar nature to that made by the Bureau of Standards on fuels in 1923 was conducted by the company the author represents, and the paper presents first the results of the tests made on five 7½-ton trucks during the regular course of business deliveries. Curves plotted from the data thus obtained are presented and analyzed in considerable detail.

These data were then utilized as a basis for a series of dynamometer experiments in an attempt to explain further the effects of the many temperature and mechanical variables on the rate of oil consumption and oil dilution when only one factor was allowed to vary at a time.

The dynamometer apparatus and the engine used are described, together with the test routine, and an analysis is made of the result of wear of the test engine. The "standard" conditions under which the test runs were made are stated. Each series of runs was made by varying only one of these standard variables at a time; all others were held constant. The runs of Series A relate to carbureter setting, and those for the subsequent series have to do with load, oil volume, crankcase temperatures, carbureter air-temperature, cylinder-jacket temperature and engine speed. Curves plotted from data obtained in each series of tests are presented and analyzed, and, as an indication of the general trend of the results that may help to solve some of the perplexing lubrication problems now current, five tentative conclusions are specified.

THE DISCUSSION

QUESTION:—Apparently, engineers devote too much energy to attempting to remedy the effects and damage done by oil-dilution. Should not more energy rather be directed toward prevention, for instance, to the elimination of the carbureter and the adoption of more scientific means of fuel introduction?

NEIL MACCOULL:—I do not understand why it is that we can find no appreciable difference in the dilution resulting from altering the fuel condition as we have done by changing the manifold temperature. It would appear that either we have nothing like the full story or that some of these specially good carbureting devices have very little effect on dilution. As I have shown, the richer the mixture, the greater will be the dilution.

QUESTION:—Why does no direct relation seem to exist between the percentage of dilution and the miles per gallon?

MR. MACCOULL:—That question undoubtedly refers to the truck test. I have no idea, except that so many other variables occur in the truck test that we have no control of them.

QUESTION:—What were the specifications for the oil used in the test?

MR. MACCOULL:—It was a naphthene-base oil. I do not know the manufacturing limits, offhand. It has a specific-gravity of about 20 deg. Baumé, a viscosity of 500 Saybolt sec., and a fire-point of about 420 deg. fahr.

QUESTION:—Does high-test gasoline dilute more than low-test?

MR. MACCOULL:—By no means. We have corroborated the Bureau of Standard's work, which showed that the lower the volatility of the gasoline, the greater the crankcase-oil dilution.

QUESTION:—Does not the distillation curve of the diluent agree with the fuel curve?

MR. MACCOULL:—To some extent, it does; but the samples of diluent taken from the engine oil varied very little, no matter what the fuel was. We had fuels that were almost as heavy as kerosene and some lighter than aviation gasoline, yet the material we got out of the lubricating oil had very nearly the same distillation curve.

QUESTION:—Was any attempt made to test the effect of a hot-spot manifold on dilution?

MR. MACCOULL:—That was not done. Our manifold is decidedly not a hot-spot manifold. We felt that it would be very difficult to determine that effect quantitatively, so we used a manifold that would prevent heat from going in or coming out above the carbureter.

QUESTION:—From the date presented, could one not draw the conclusion that a thermosiphon engine which runs hotter, both as to water and crankcase temperatures, would give less dilution than a pump-cooled engine?

MR. MACCOULL:—I do not see why a thermosiphon engine should be any hotter than a pump-cooled engine that has a proper thermostatic regulator. Either method would cause a warm jacket-temperature, and that apparently is very much to be desired. The hotter the engine, the less the dilution, naturally.

CHAIRMAN T. J. LITLE, JR.:—I think that is right; thermosiphon engines tend to run warmer, particularly in winter. There is actually no circulation at all for a while. With a thermosiphon engine, you have no circulation until you need it.

QUESTION:—No mention has been made of sludge carbon or metal particles being found in the crankcase.

MR. MACCOULL:—That was, of course, entirely outside this particular investigation. Not enough sludge would be found in our short runs to be measurable. I presume the question was asked with the idea of determining how often the oil should be changed, since the question of changing the oil is more dependent on the foreign particles in the oil than on the drop in the viscosity.

QUESTION:—Have you ever made tests with engines that showed a dilution that balanced the consumption? If so, what harmful effects on the engine were observed?

MR. MACCOULL:—I ran a test at one time with a kerosene fuel in which apparently the crankcase contained more oil after the test than when it began. That simply means that the rate of dilution was greater than the oil consumption; I do not see that it necessarily means anything in itself.

After the viscosity of the oil has dropped considerably, how far I do not know, the oil naturally becomes too thin and should be changed. The mere fact of getting the fuel into the oil faster than the oil is burned up is, in itself, not an element of harm unless the user of a car experiencing that phenomenon thinks he has no oil-consumption and, therefore, lets the car ride by itself a few thousand miles. That has often happened, unfortunately.

[4] M.S.A.E.—Automotive engineer, Texas Co., New York City.

QUESTION:—Would you recommend heating the oil-pan to maintain temperatures higher than those in use at present?

MR. MACCOULL:—Yes, if it can be done without too great expense.

QUESTION:—Please explain more fully the relation between the intake-gas temperature and the dilution. Do you say that, although much liquid fuel was carried over at 100 deg. fahr., no more dilution was noted than at a higher temperature?

MR. MACCOULL:—That is precisely what happens. I stated that I do not know why that should be unless the temperature of the residual gases in the cylinder were high enough to vaporize all the liquid going through the manifold.

QUESTION:—Were the tests run at a constant engine-speed?

MR. MACCOULL:—All except the last series.

QUESTION:—In places where engines run 18 hr. out of 24, when the temperature is constant, would it be possible to eliminate oil-changing to the point where the question would be one of too much dirt; in other words, to adjust the amount of oil in the crankcase so that it would be closer to the amount consumed? I believe the objective we want to reach is the increasing of the number of miles covered before it will be necessary to change the oil, and the designing of some method that will produce this effect. Today we add gasoline oftener than we add oil.

MR. MACCOULL:—I think that is entirely true. Ordinarily, when drained, the oil itself is not broken-down. It is simply mixed with particles of foreign matter and fuel, both of which can be removed by the proper methods. If you can reduce the fuel dilution by proper temperature-regulation and can provide a method of cleaning the dirt out of the oil as fast as it gets in, I do not see any reason that the oil should be drained and thrown away.

OTTO M. BURKHARDT:—Our biggest problem has been the formation of sludge, which is produced more or less by any foreign matter in the oil. Water causes dilution. Silicon and particles of dirt and metal cause contamination. I would like very much to hear from persons who have devised means of eliminating foreign matter, either by distillation or by filtering.

J. O. EISINGER:—We have done some work on the effect of changes in the oil circulation on dilution; it is not complete as yet but bears out the same thing that Mr. MacCoull found, that an increase in the oil circulation does decrease dilution.

In his paper at the Semi-Annual Meeting last year[5], the late S. M. Lee showed the negligible effect of the temperature of the carbureter air on dilution; which bears out the same thing that Mr. MacCoull brought up. We intend to study not only dilution but also contamination. I think contamination, which includes dilution and the inclusion of foreign particles, is a big problem.

R. W. A. BREWER:—Mr. MacCoull did not tell us how he measured the dilution, nor how the quality of the oil was affected by the measured amount of dilution. I accentuate the word "measured," because, in the system that I use and have decided upon as a result of a number of trials to determine the amount of dilution I agitate the oil as severely as I can in the apparatus during the time that the heat is applied. It probably is a fact that an increase in the rate of oil circulation tends to liberate the diluent from the oil; this probably affects the actual measured dilution when the oil has been pumped in large quantities under high pressure. It may not affect the actual dilution but only the dilution that occurs and remains in the crankcase oil.

F. G. KLOCK:—We ran some road-tests at high temperatures last summer, that practically duplicate Mr. MacCoull's findings. We ran tests of oils of different bases and found that lubricating oils with lower distillation-curves in long tests retain their viscosities close to the original, or even higher, better than do oils with higher distillation-curves.

O. C. BERRY:—One thing that, to my mind, is very important in determining crankcase-oil dilution has not been mentioned—the temperature control of the intake-manifold. In carbureter tests on engines we find that some engines, even in warm weather, require 2.5 miles of continuous running before they reach a temperature at which they can give their best performance; that is, with the carbureter adjusted to give the highest economy at the normal operating-temperature. Other engines do the same thing in 0.2 mile.

Mr. MacCoull said that, in his estimation, the fuel probably was well enough vaporized in the manifold so that the piston-heads and valve-heads would do the rest of the vaporizing, and that the dilution would not be great, on account of the temperature of the manifold. That may have been, and probably was, the case, in his test, but it is not the case at lower temperatures. The amount of dilution occurring at the starting-temperature is great as compared with the dilution after the engine has been warmed-up. To my mind, one of the most important things we must do in the future is to study the proper application of heat to the intake-manifold.

CHAIRMAN LITLE:—Do you feel that it would be better to have the engine too hot than too cold?

MR. BERRY:—The only things we suffer from in using a little too much heat are that the power drops slightly, and that, in case the matter of high compression has been overdone or the exhaust-valve heads or the spark-plugs are entirely too hot, a tendency toward detonation is noticed. I prefer the hotter manifolds, along with the necessary lessened compression and power, to the colder ones with their crankcase-oil dilution, long warming-up periods and waste of fuel. The former will certainly give the average driver much better service and satisfaction. It is my impression that the intake-manifold should have a hot-spot that is very hot, right over the carbureter. The metal in the hot-spot should have a low heat-capacity and the heat should be concentrated right on the hot-spot, which should not have too much area but just enough to do the work under average running-conditions.

As for the temperature of the metal that is required to vaporize the fuel, I find that as the metal is heated from 0 deg. fahr., you will not do much vaporizing with the best grades of gasoline until you get to 400 deg. fahr. You can raise it to 1000 deg. fahr. and not change greatly the amount of fuel that will be vaporized on the same area. So long as the hot-spot itself is covered with a film of liquid fuel the temperature of the metal makes very little difference in the amount of heat transferred to the mixture, because the air in the mixture is exposed merely to the temperature of the vapors of the fuel layer on the hot-spot wall. No danger of getting the hot-spot temperature high enough to ignite the mixture in the intake-manifold seems to exist, and the higher temperatures assure comparative freedom from carbon deposits on the hot-spot due to cracking the fuel, because the

[5] See THE JOURNAL, July, 1923, p. 3.

liquid fuel will rest on a film of its own vapor and not touch the hot metal.

H. E. A. RAABE:—My firm has made very extensive experiments along this line, and one of them has proved very interesting and very gratifying as to results.

Instead of introducing into the manifold hot-spots that are more or less ineffective, because a large area must be exposed to the fuel to vaporize it properly, as the fuel passes such spots at a very high velocity, we have heated the gasoline before introducing it into the carbureter. We constructed a special vessel with a double wall forming an inner chamber for the passage of gasoline, the outer jacket being heated by exhaust gases. We eliminated entirely the dilution of the lubricating oil, not in laboratory tests alone but actually on the road, through several months of trial; and we also cut down the fuel consumption about 25 per cent. Of course, this is a different subject from the one under discussion, but my idea is that the fuel which we have at present is not volatile enough to vaporize under ordinary atmospheric conditions, and that in our present-day high-speed engines the fuel passes through the manifold at so great a velocity that practically the entire manifold must be heated to be effective; and that even then the fuel will not vaporize properly. But while the gasoline is in bulk, and its volume is small, it can easily take up sufficient heat to increase the volatility of the fuel so that it will vaporize properly when released from the spray nozzle. The thing to do is to increase its temperature, so that it will be more volatile than it would be at the temperature of the atmosphere.

CHAIRMAN LITLE:—How high?

MR. RAABE:—About 100 deg. fahr.

MR. MACCOULL:—Since I have recommended eliminating the conventional spring-loaded bypass valve from pressure lubricating-systems, it may be well to analyze the performance of the systems in which they are used. Consider first what happens when starting a new engine with well-fitted bearings during cold weather. The bypass is supposedly set to maintain a pressure such that the oil consumption under running temperatures will be normal. It is easy to see that most of the oil will pass through the bypass, for the volume passing through the bearings is a function of the oil viscosity and at low temperature the oil may easily be 100 times as viscous as at operating temperatures. The engine is thus starved of oil when starting cold, and the more careful the manufacturer is to provide tight bearings and the owner to drain his oil frequently to maintain a high viscosity in spite of dilution, the more surely will the engine be starved at this period. Although an engine with cast-iron pistons can be starved for a few minutes without apparent injury, this is not the case with aluminum pistons. As evidence of the truth of this phase of lubrication, observe the number of pressure-lubricated engines that have recently gone back to iron pistons; yet their performance under heavy duty, as in airplane engines, is known to be very satisfactory.

Secondly, as a corollary from the first, notice that a high oil-pressure means a large bypass discharge, and hence, in general, a small flow to the bearings and the cylinders; conversely, a low pressure means a large flow. This is not the impression given the driver who watches his oil-gage, who greatly desires a high pressure; when it is low, gets worried and wants to change the oil to bring the pressure up.

Thirdly, consider an old engine with large bearing-clearances. As the clearances enlarge with age, a larger and larger proportion of the oil will pass through the bearings, provided the oil pressure is held constant. Eventually, all the oil from the pump will pass through the clearances and none through the bypass. From this time on, further bearing-wear will cause no increase in the volume of oil passing through the bearings, since it will be limited by the size of the pump. As shown by Fig. 10 of the paper, the more oil passing through the bearings, the greater will be the oil consumption; consequently, in an old engine, the larger the pump, the

TABLE 1—PROPORTIONS OF OIL-PUMPS OF PRESSURE-LUBRICATED ENGINES

Engine	Displacement per Engine Revolution, Cu. In.				Normal Oil-Pressure, Lb. per Sq. In.	Desired Crankcase Condition
	Engine	Oil-Pump	Equivalent for 1000-Cu. In. Engine			
			Pump	Through Bearings		
Buda	226 312 382 510	0.24 0.24 0.35 0.35	1.08 0.78 0.91 0.61	......	10.0	......
Buick	170 191 255	0.21 0.21 0.21	1.23 1.10 0.83	0.25[b]	30.0[a]	......
Cadillac	314	0.58	1.80	0.24[c]	10.0[d]	......
Cleveland	199	0.32	1.60	......	50.0	......
Climax	510 665 995	0.50 0.50 0.90	0.98 0.75 0.91	......	10.0	Cold
Dorris	377	0.44	1.17	0.58	25.0	150 Deg. Fahr.
Falls	196	0.44	2.24	......	5.0 to 45.0	......
Franklin	199	0.12	0.60	0.24	45.0	Cold
Haynes	274	0.47	1.72	......	20.0	Cold
Jordan	246	0.47	1.91	......	25.0 to 30.0	Cold
Locomobile	525	0.60	1.14	......	5.0	Warm
Lycoming	192	0.37	1.93	......	....	Cold
Nash	250	0.37	1.51	0.30[b]	25.0	Cold
Northway	240 276 382	0.39 0.39 0.59	1.64 1.43 1.54	......	17.5	130-150 Deg. Fahr.
Oakland	177	0.10	0.57	......	10.0	......
Packard	268 358	0.25 0.38	0.93 1.05	......	42.0[e]	Cold
Paige	331	0.42	1.26	......	30.0 to 40.0	Cold
Peerless	289 332	0.29 0.29	0.99 0.86	0.70[b]	35.0 15.0	Warm
Pierce	415	0.69	1.67	......	....	Cold
Waukesha	222 346 490 570	0.17 0.17 0.29 0.29	0.78 0.50 0.59 0.50	0.16[f]	6.0 to 8.0 6.0 to 8.0 15.0 to 18.0 15.0 to 18.0	Cold
Willys-Knight	186	0.18	0.97	0.20	....	......
Wisconsin	252 340 470	0.40 0.60 0.60	1.59 1.76 1.28	......	12.0 to 15.0	Cold
Average Practice	....	....	1.24	......	23	......
Airplane Engines						
Benz	1070	0.20	0.19	......	....	......
Liberty	1650	0.27	0.17	......	....	......
Maybach	1412	0.16	0.11	......	....	......
Mercedes	900	0.08	....	0.09[g]	....	......
Average	....	....	0.16	......	....	......
Mercedes Automobile Engines						
Knight-Type	248	0.024	......	0.10[g]	....	......
Six-Cylinder	445	0.049	......	0.11[g]	....	......
Diesel						
German Submarine	24,000	....	....	0.35[h]	....	......

[a] Maximum.
[b] Approximately.
[c] Average of bearing-flow at 100 and 1000 deg. fahr.
[d] At 140 deg. fahr.
[e] Cold oil.
[f] Bearing-flow measured for new engines.
[g] No by-pass valve used.
[h] Navy-Yard test.

more likely will be the trouble from fouled spark-plugs and excessive carbon.

To get an insight into the average practice in proportioning oil-pumps, I have collected the figures given in the following Table 1. Circular letters were sent to practically all the builders of pressure-lubricated engines, but less than one-third sent replies. Even among these, several gave figures that we found were very incorrect when checked up. Nevertheless, we believe that the values given are representative of normal design and practice of the present time.

Notice that the average capacity of oil-pumps in American cars is about eight times as great as that in airplane engines and the Mercedes automobile engine, when the same sizes are compared. This means that correspondingly greater attention must be paid to piston-rings to avoid the evils of over-oiling.

Before closing, I wish to call attention to the fact that the object of the research I have described has been, primarily, a study of oil consumption. Dilution has been a secondary consideration. We plan to carry on much more work of this sort with the idea that some of it will be useful to engine builders. Accordingly, we shall appreciate suggestions from manufacturers and designers as to the lines on which they would like to see these lubricating problems attacked.

RECTIFICATION OF DILUTED CRANKCASE-OIL

BY RALPH L. SKINNER[6]

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

IT is generally recognized that the dilution of crankcase-oil with water and unburned fuel tends to accelerate the wear of engine bearings, cylinders and pistons. The author traces the engineering development of a rectifying device and system designed to combat this problem. In this system, diluted oil that tends to work-up past the pistons, in company with the water vapor and unburned fuel that tend to work down into the crankcase, is drawn from the cylinder walls and pistons by vacuum. This diluted oil is conducted into a still or rectifier where it is subjected to heat from the engine exhaust. The heating action is just sufficient to volatilize the fuel and water, the resulting vapor being returned to the intake-manifold and thence to the engine where it is burned. The lubricating oil that remains behind is conducted back into the crankcase. The system functions automatically. A float-actuated mechanism controls the flow of the diluted oil through the rectifier, and a thermostatically-controlled valve regulates the degree of heat to which the liquid is subjected.

Troubles encountered in the early stages of development of this device and the means employed to overcome them are described. Temperatures prevailing throughout the system when it is in operation are given. Data relating to the volume of oil handled by the device in ordinary service are presented.

Comparative tests to determine engine wear with and without the device are described. In one of these, dust was intentionally introduced into the intake-manifold to determine whether it was detrimental to engine life when dilution was and was not present. Based on these and other test results, the author expresses the opinion that an ordinary amount of dust is not harmful if the oil is maintained at somewhere near its initial viscosity by a rectifying device. Relative-wear data are presented in curve form.

Crankcase-oil dilution is one of the main obstacles to be overcome before fuels of low volatility can be burned satisfactorily in automotive engines of the present day. The author states his belief that the use of a rectifying system to drive off the diluents from the lubricating oil and prevent their reaching the crankcase will assist in conserving the supply of petroleum fuels.

THE DISCUSSION

CHAIRMAN ROBERT E. WILSON:—Is there danger of taking too much oil off the piston?

R. L. SKINNER:—We have run tests to determine the answer to that question. A vacuum-pump was attached to a six-cylinder engine running at 3000 r.p.m. at full load. The vacuum-pump maintained a vacuum of 22 in. on the piston-ring, yet, under this extreme condition, it was impossible to notice any difference in the heating of the engine or to see any bad effect.

On this test, we removed 5 gal. of oil from the side of the piston in 1½ hr.; so you can see the amount of oil that this system will put into circulation.

QUESTION:—How much oil does this device draw from the pistons of an ordinary six-cylinder engine and how does the quantity drawn off vary with the speed of the engine?

MR. SKINNER:—When the intake-vacuum is used as the source of power in removing the oil from the ring-groove, the amount of vacuum applied to the ring-groove will vary inversely with the acceleration of the engine. In other words, when accelerating at high speed, the vacuum is very low, so that not so much oil is sucked off per revolution of the engine at high speed as at low speed. Normally, 1 qt. of oil is removed from a car every 5 to 9 miles.

QUESTION:—How high a vacuum is required to operate the device? Has the intake-manifold of a heavy-duty engine sufficient vacuum at full load?

MR. SKINNER:—We have run this device on tractors and have obtained the results that we have shown. I appreciate, of course, that in a tractor the vacuum fluctuates, but a tractor is used under nearly full-load conditions most of the time, so that the vacuum is much lower than that encountered in automobiles or motor trucks. Tests made under severe conditions over a long period of time have shown this vacuum to be ample for the oil rectifier to function properly. We have had no experience with heavy-duty marine engines, and it may be necessary to have other means than the intake-vacuum to produce vacuum enough to remove the oil.

QUESTION:—What is the temperature of operation?

MR. SKINNER:—The temperature of the oil, when removed from the piston, is substantially the same as that of the crankcase oil. As the thermostat is set at 150 deg. fahr., the temperature of the oil in the top of the system very seldom gets much higher than that. The temperature of the gas in the top of the engine, as I have explained in the paper, may run as high as 500 deg. fahr.

QUESTION:—Does the shape of the piston-head, that is, whether it is concave or convex, affect the amount of dilution?

MR. SKINNER:—We have never gone into that matter

[6] M.S.A.E.—President and manager, Skinner Automotive Device Co., Inc., Detroit.

at all. We have, however, run an oil rectifier on a Pope-Hartford automobile that had a concave head, and could not note any difference. The dilution was just as apparent in the Pope-Hartford as it was in the car with the flat piston-head. We have also run it on a Knight engine having a convex head. The dilution percentage was the same as with a piston having a flat head.

QUESTION:—Have you made tests when a quantity of gasoline was added to the crankcase-oil? If so, would the device take the gasoline out of the oil?

MR. SKINNER:—In one test, not made by us, but by an engine company, in which they used an oil having 56 per cent dilution, 6 per cent water, the water was entirely gone in 100 miles, and in 200 miles the dilution had been reduced to 6 per cent.

OTTO M. BURKHARDT:—Mr. MacCoull showed that, in an engine that is in poor mechanical condition, the viscosity drops very rapidly; which is an indication that dilution is taking place very rapidly. We could see from his diagram that after the engine had been overhauled the viscosity rose quickly and consequently the dilution fell off. In other words, to do away with dilution, the best thing to do is to build the engine right, and, when the engine is worn-down, overhaul it.

If we put Mr. Skinner's device on a new engine that is built right, what will happen? It has little work to do while the engine is new and after some 500 miles it may be clogged up, while by that time the engine will develop dilution.

We know that, besides dilution, we have carbon formation, which causes sludge. The sludge is sufficient to plug up a 1-in. hole in a crankshaft. I have taken "sausages" 1 in. in diameter out of a crankcase. In this case, what would this sludge do to the small orifices in the device?

We all have seen pistons, with the rings removed, having a crust of carbon formed back of the rings. The fine orifices back of the rings become clogged by this crust and I wonder whether they will then allow the vapor to pass.

Another question is, What will happen in cold-starting? Large snugly-fitting engines are hard to turn in cold weather. Considerable leakage always occurs. I am very keen on providing packing for the throttle-valve and seeing to it that the valves do not ride, because I am very sure that otherwise a large engine would not start.

In a six-cylinder or an eight-cylinder engine, we have with this device six or eight orifices to leak through. How much of a problem would it be, with all this leakage, to get started with the ordinary gasoline that we are getting today?

Further, I have seen an engine that had been started in ordinary winter weather, then stopped after a minute's running, restarted in 5 min., stopped after another minute's running, started again after 5 min. and stopped again. A crust of ice had formed by the time the engine was dismantled. This crust of ice formed on the top of the pistons, the water never coming down to the third ring whence the device removes it. This is one of our main starting-problems in high-grade cars. Will this be avoided?

MR. SKINNER:—With regard to tight fits, the sample of oil that I just mentioned was taken from a car that had a high percentage of dilution; it came from a practically new eight-cylinder engine that had run only 350 miles. I think that is the answer to the tight-fit question.

So far as the small hole is concerned, nothing but vapor comes through the small hole back of the piston-ring. In addition to preventing the dilution, we prevent the oil from staying behind the ring itself in the bottom of the ring-groove.

If you can keep an oil active, you can subject it to high temperature without carbon being formed excessively, but the moment you keep the oil stewing and do not allow it to become active, this compartment back of the ring will gradually fill up with carbon; and, naturally, if that condition existed in our system, the little hole would become plugged. We have, however, run systems in California for considerably more than 150,000 miles; the little hole is still open and has not shown any signs of stoppage.

Starting is one of the greatest obstacles we have overcome. If you keep the proper oil-seal on the cylinder itself, you naturally will have better compression in the combustion-chamber. That in itself will enable you to start the engine more easily. If you allow the oil to become diluted in the crankcase, in which case you have this seal, naturally you will have trouble in getting adequate compression in the combustion-chamber and will have trouble in starting.

So far as having a crust of ice on the top of the piston is concerned, we have never encountered that trouble.

MR. BURKHARDT:—You spoke about tests in California. How about Minneapolis, Montreal and St. Paul?

MR. SKINNER:—Put Toronto in, too. We have had devices running during the last winter in Milwaukee, Minneapolis, Bangor, Me., and Watertown, N. Y., where the temperature was down as low as 30 or 35 deg. below zero fahr. Absolutely no trouble was experienced.

QUESTION:—If no dust were present, would a dilution of, say, between 20 and 30 per cent, of an oil having an original viscosity of 300, result in excessive wear, and, if so, why?

MR. SKINNER:—I think that has been clarified by tests run by the General Motors Research Laboratory at Dayton, in which they put kerosene into the crankcase of an Oakland engine and ran the engine for some time without excessive wear. The moment that carbon began to form and they put in a diluted oil from another car, considerable bearing trouble was encountered and the engine siezed. We have never run tests that way. Our problem has been to obviate dilution.

QUESTION:—How did you determine dilution? Is it not true that unused oil has about 5 per cent dilution?

MR. SKINNER:—We have used the same system that the Bureau of Standards uses. We take 100 cc., put it into a distilling-flask, and run the heat up to 310 deg. cent. (590 deg. fahr.). The fluid that distills over at this temperature we call the dilution. If we run the oil up to to 320 deg. cent. (608 deg. fahr.) we get some of the low fraction of oil, but we find that a margin of safety of 15 to 20 deg. exists after getting dilution before we get the low fractions of oil.

QUESTION:—Have you ever added sulphuric acid to crankcase oil and removed it by the device?

MR. SKINNER:—A test was run by a company in Detroit in which a liquid soap was put into the oil in the crankcase. The car was run on benzol to get the corrosion trouble that has been under discussion. The test was run in January, 1923. They were unable to get corrosion.

We have never put in sulphuric acid because I think that sulphuric acid will not form without water. Why put in the sulphuric acid itself?

QUESTION:—What is the largest size of particle that

is too small to cause appreciable wear, if the oil is of the viscosity recommended by the manufacturer?

MR. SKINNER:—We know that, with the ordinary amount of dust that is in the engine, if we can keep the viscosity of the oil up, the amount of wear will be reduced very appreciably. I have never known of anyone measuring the diameters or giving an idea of how thick or of what size the particles are in the crankcase, except in the case of the data we have given. The particles appear to be approximately 0.0001 in. in diameter.

QUESTION:—Have you run any tests in which Oildag was used in the engine? What is the effect of graphite?

MR. SKINNER:—We have never run any tests with Oildag.

R. C. DARNELL:—With your device, the dilution is still bad on the upper rings of the piston. Will you explain why no wear was obtained?

MR. SKINNER:—That is very hard to explain. We have found that it is not only the ring that causes wear, but the thrust of the piston more than anything else. With an aluminum piston, the trouble does not occur on the rings themselves but on the skirt of the piston. The pressure is put on the cylinder wall by the explosion thrust. If the dilution of the oil is kept up where the thrust really comes, the ring pressures, which very seldom exceed from 5 to 7 or 9 lb., will not cause excessive wear.

MR. DARNELL:—I meant the wear on the ring-grooves. You showed us some pistons in which the rings looked very fine. I wondered why it was, when you had so much dilution in the ring-grooves themselves, that you had so little wear.

MR. SKINNER:—The pounding-out of the ring-grooves does not come when you start. It comes after continued operation. If a little film of oil is put there, it acts as a cushion.

MR. DARNELL:—But you pull the oil off before it gets to the grooves.

MR. SKINNER:—We cannot pull it all off. That would be impossible. We reduce the amount of oil to the minimum. If you get a little good lubrication, it is not necessary to have the top of the piston even damp. We have run pistons from 30,000 to 40,000 miles with 0.001 or 0.002 in. of resultant wear on the ring-groove and the ring. It was really remarkable and shows that a little oil of the proper kind is much better than a large quantity that is not good.

CHAIRMAN WILSON:—Have you done any work to determine the effect of the device on the amount of oil that leaks to the top of the piston-head and produces carbon?

MR. SKINNER:—A test of a tractor engine with 0.011-in. side-play in the piston was run at the General Motors Research Laboratory some 2 or 3 years ago. The rings were purposely fitted into the grooves with 0.005 to 0.007-in. side-play. Enough oil was put into the crankcase so that the connecting-rods were dripping over 2 in. The tractor nominally held 4 gal. However, 8 gal. was put in the crankcase. The cylinder-head was removed. Another engine was used to drive this engine with a belt. The vacuum supply was furnished by connecting the intake-manifold of the driving engine to the engine on test. The engine was run for 5 min. During that time a very small portion of oil appeared around the edges of the pistons. Without the system, the entire top of the piston was covered with oil, and surplus oil was flying all over it in less than 1 min. I think that answers the question whether the amount of oil that goes up can be materially reduced.

T. S. SLIGH, JR.:—I understand that Mr. Skinner said that, when carbon was formed in the oil, wear began. I would like to have him state whether he believes that carbon from the oil is an abrasive.

A second point is regarding the extremely small size of the dust particles taken from the oil drawn from the crankcase. Those dust particles had obviously been drawn through the combustion-chamber and past the pistons, and had probably been very much broken-down in the passing. Is the size of those dust particles large or small as compared with the size of the dust particles that go into the carbureter?

MR. SKINNER:—We have never determined the size of the dust that goes into the carbureter. The dust that goes into the engine is only the dust that will float in the air. We have no way of telling whether the wear begins when the carbon forms in the oil. It seems that, as graphite is a form of carbon, wear would not come from its presence in the oil.

W. G. WALL:—Mr. Skinner has been doing work that is very important. In fact, it is absolutely necessary for the future development of the gasoline engine that the dilution question be solved. Mr. Skinner has one way of solving it. We may not agree with him entirely on the kind of apparatus he uses, but there is no question about the oil rectifier's being a necessity. I think that in time the use of oil rectifiers will be universal.

With slow-speed engines, 15 or 20 or even 12 years years ago, I do not believe that we stopped as often as we do now in city traffic; it was not necessary, with the kind of gasoline we used, to worry very much about crankcase-oil dilution. But, with the high-speed engines of today and the kind of gasoline we are obliged to use, the case is entirely different.

The idea that dust and dirt are causing wear of the connecting-rods, crankshaft bearings and so forth is probably right to a certain extent; and we know that part of the wear of the pistons is caused by particles of foreign matter. We know also that the carbon deposit is composed largely of dirt, so that an air-cleaner is a very desirable adjunct to an engine, although not so important as an oil-rectifier.

Although many engineers think that we should attack this problem at its source, that is, make the combustion complete (which we should all like to do), or, by heating the intake-manifold, vaporize the gas, or, by atomizing the gas, prevent a large amount of dilution, we know that there is a limit to what can be done. We all have tried heating the intake-manifold. By carrying this far enough we can cut down the power probably 25 or 30 per cent. We must use merely sufficient heat to get the proper distribution and the proper ignition. I think that we shall have to depend on the oil-rectifier to take care of the dilution.

QUESTION:—What becomes of the water?

MR. SKINNER:—The water or moisture is conducted through the rectifier where it is vaporized and conducted back into the intake-manifold. In fact, it does not have a chance to condense. It is still steam when it goes by the rings and the pistons.

F. E. MOSKOVICS:—Verifying Mr. Skinner's conclusion that proper oil is much more important than keeping the incoming charge clear of dust, I cite as an illustration a model of car which was equipped with a dust separator but did not have sufficient cylinder lubrication for its entire speed-range. The cylinder wear in a large number of those cars was excessive; as much as 0.006 or 0.007 in. after 2000 or 3000 miles of use. By simply adding more oil to the cylinders and lubricating them

properly, the wear was entirely stopped. There was no dust to speak of in the oil. I think that, unquestionably, oil of the proper kind in the proper quantity at the proper place will reduce wear considerably more than will keeping dust out of the engine.

C. B. DICKSEE:—Mr. Burkhardt has suggested that the best way to avoid dilution trouble is to prevent dilution from taking place, rather than to eliminate it after it has occurred. A very small thing that will change the condition as to dilution very considerably. In testing some engines, we noticed that certain ones had ceased to "consume" oil; in fact, that, when the oil-filling plug was removed, oil ran out of the crankcase. The first impression was that somebody had probably made the mixture excessively rich. A check with an Orsat apparatus showed that this was not the case and, on examination, it was found that the side of the rings, where they fitted into the pistons, were slightly undulating, by an amount not more than 0.0005 in., and that these slight undulations allowed the fuel, which was kerosene in this particular case, to get down to the crankcase at the rate of nearly 1 gal. in 24 hr.

Rubbing these rings on a surface-plate with emery for 5 or 10 min. entirely removed the trouble. A very slight discrepancy in matching can cause a considerable amount of dilution.

L. M. STELLMAN:—I hesitate to discuss this question because, dealing with air-cooled engines, our problem is a little out of the ordinary but, inasmuch as we have worked with Mr. Skinner, I would like to comment on our results. In the first place, some of the speakers have discussed the heating of the crankcase to prevent dilution of the oil. We had some experience with that about 7 or 8 years ago. The idea at that time was not to prevent dilution. As you know, owners of air-cooled cars think that they can subject them to almost any temperature. Because of this we had the problem of getting oil to flow at low temperatures. To do that, we put on a crankcase heater, through which exhaust gas passed underneath the crankcase, trying to warm the oil quickly enough so that it would begin to flow at temperatures below zero and lubricate the engine properly.

We succeeded in doing that but got into the problem of water in the crankcase, which became very serious. The crankcase acts as a condenser under those conditions and, if you stop while the engine is warm, as it usually is, water from the atmosphere condenses on the inside walls and runs to the bottom of the oil-pan where the oil-pump is located. When the engine cooled-down, the oil-pump froze, so that, when the engine started, the oil-pump shaft was twisted off. That is one problem that will be encountered when one begins to heat the oil-pan to avoid dilution.

The operating temperature of our engine cylinders varies from 20 or 30 deg. below zero fahr. to about 300 or 400 deg. above, and the problem of dilution has seemed, in our case, to be rather critical. Before Mr. Skinner came, we had experimented with all the devices we could devise and those of others, but had not been very successful. We have been working with Mr. Skinner's device for about a year and a half. During the last winter we had about 20 devices of his make operating about the Country on our regular production cars in the hands of the owners. Mr. Moskovics pointed out that we had some trouble recently from not feeding oil enough to the cylinder-walls. However, after correcting that, we found that the dilution eliminator worked satisfactorily, kept the oil from becoming diluted, materially reduced piston and cylinder wear and materially decreased the carbon deposit in the combustion-chamber and also between the rings. Just why this should be the case on the three rings above the lower ring, using four rings on the piston, I am not able to state. The rings do remain free under all conditions of operation, as nearly as we can tell.

We have driven two or three cars on which this device was installed across the Continent and back, and some without it, all with aluminum pistons. The increase in clearance between the cylinder-wall and the piston in one car with the device attached was 0.0015 in. maximum after about 10,000 miles of operation. We have about one-third the wear with the eliminator that we had without it under similar warm-weather operating-conditions. This is not intended as a testimonial for the device, but so far we have not found the "bug" in it; though we are still looking, we think that the device is very good and fulfills the claims of Mr. Skinner.

CHAIRMAN WILSON:—We should not be too hasty in coming to a conclusion as to what is the most important factor in wear, merely because we can stop the wear by correcting some one condition. It seems to be fairly well established that if we stop dilution we can have much more dust without getting into trouble. On the other hand, I believe that it is almost equally well established that, if we keep dirt out entirely, we can stand a great deal more dilution. Both are undesirable, of course, and one or the other must be eliminated to cure the present condition. It is simply a question of which is the easier, safer and better way of stopping wear: eliminating dust or preventing dilution, or removing the latter after it has occurred, or a combination of both remedies.

A MECHANICAL CONTINUOUS-TORQUE-VARIABLE-SPEED TRANSMISSION

BY EDWARD B. STURGES[1]

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

POWER-TRANSMISSION devices may be classified into two general groups: those having intermittent or step speed-changes and those having contiguous or curve speed-changes. The increasing demand for a positive variable-speed power transmission, particularly since the introduction of the internal-combustion engine, which has very limited flexibility, has resulted in the development of the step speed-transmission unit to the limit of its practical possibilities. The difficulties of the conventional gearset have led to the invention of many devices for transmitting as nearly as possible the changes of an infinite number of speed-ratios between the driving and the driven members. Although the number of speed changes that may be obtained with the friction type of transmission is in-

[1] Secretary and treasurer, Weiss Engineering Corporation, New York City.

finite, the changes are nevertheless of the step type and are not positive. A serious handicap also is the fact that the torque radius of the driving member is inversely proportional to the torque of the driven member.

To overcome these difficulties, the variable-speed power transmission described in the paper has been designed. This consists primarily of a nutating power-transmitting body called the mutor, inclosed in and concentric with a metallic sphere. The nutating body or mutor is equipped with clutch elements that co-operate with the inside surface of the sphere, the transmission being designed so that the relative angular axial positions of the mutor and the sphere may be varied, the mutor nutated and the rotation transmitted from it. Power is transmitted from the driving to the driven member through the mutor which, receiving its movement of nutation from the driver, acquires from it a continuous movement of rotation about its own axis and transmits it to the driven member.

Among the salient characteristics of the system are said to be the following: It is highly efficient and not subject to great wear, is positive in transmission for all speed-ratios and for all loads, and maintains constant uninterrupted action during all speed variations; the torque does not react on the speed-control mechanism; the torque-radius of the driving and that of the driven element are equal and remain constant at all speed-variations; the torque capacity increases approximately as the cube of the diameter of the transmission; in the zero position the driven element is at rest and is locked against rotation in either direction, without angular reaction on the driving element or upon the control, regardless of the speed of the driving-shaft; and contiguous or curve speed-changes are possible at speeds varying from zero to the maximum. Through these characteristics the way is opened to automatic torque-control through a torque governor that produces the proper reduction-ratio automatically through torque-reaction on the speed-controlling member.

A brief general discussion is given of the kinematics of the subject and is followed by detailed descriptions of the single-sphere heavy-duty-type transmission and the medium-duty type. Views of several types that have been tried out in automobile service are shown.

Among the advantages claimed for this transmission system as applied to automobile use are simplicity of control; greater safety; superior flexibility in starting and greater speed for the same engine horsepower in climbing hills; economy of fuel through ability to use a higher gear-ratio in the rear axle, hence giving greater car-speeds without causing the engine to race, and incidentally adding to the comfort of passengers; possibility of the use of a lighter engine, because of the ability to produce infinite speed-reduction and therefore infinite leverage; capacity to climb any hill within the friction-coefficient of the wheels to the road; and the fact that the horsepower capacity to which the transmission can be built has no limit.

THE DISCUSSION

CHAIRMAN J. A. ANGLADA:—What is the unit pressure between the mutor surface and the sphere where they are in contact?

E. B. STURGES:—The ball bearings form the contact between the mutor and the sphere, and each ball bearing takes its share of the load, in contrast with ball bearings as used ordinarily, where the weight is mainly on the lower ball. The transmission is designed with a sufficient number of bearings at a sufficient distance from the axis so that the driven shaft will be twisted off before the transmission itself will be injured. The load capacity of each bearing is known, and the machine is designed so that this load never will be exceeded.

CHAIRMAN ANGLADA:—To get a drive, what is the calculated coefficient of friction between the contact surfaces?

MR. STURGES:—The arc of the supporting grooves can be determined best by trial. It must be so shallow that slippage will never occur. If it is very shallow, the pressure is practically at right angles and no tendency to slip exists. The coefficient of friction that we use is 0.1763.

CHAIRMAN ANGLADA:—Is there no slippage in the contact between the mutor and the spherical surface, the same as in the ordinary cylindrical friction transmission in which a slippage exists between the mean width and the outside edges?

MR. STURGES:—No slippage whatever occurs. The outer race of the bearing is ground down to a radius smaller than that of the sphere. In a commercial type, the outer race should be made larger than the standard bearing, to give a heavier section. We have used standard bearings so far, but an outer race of the next larger size of ball bearing probably should be inserted. We have, theoretically, point-contact, inasmuch as the arc is smaller than the arc of the sphere, the pressure between the surfaces depends upon the load on the driven shaft, and constant rolling occurs on a path like that shown in Fig. 3 of the paper over the surface of the sphere. Each bearing rolls up on a tangent and rolls back on a tangent; no slippage whatever exists.

GEORGE W. CRAVENS:—Am I right in thinking that compensation for wear is accomplished by a wedging action and that the amount of friction is limited only by the pressure?

MR. STURGES:—Yes.

MR. CRAVENS:—Then, as this ball-bearing rolls inside the sphere in the irregular path shown in Fig. 3 of the paper, a small tendency exists for it to twist, the same as a front wheel on a car tends to slide and wear a tire if it is out-of-line. How is that surface lubricated?

MR. STURGES:—By splash lubrication; the whole transmission revolves in oil. The bearing cannot twist as it is held rigidly in line with the axis of the mutor in whatever position the latter takes.

MR. CRAVENS:—To what degree of accuracy do you grind the inside of the main sphere; to how many thousandths of an inch?

MR. STURGES:—To within a few thousandths of an inch; great accuracy is not necessary. From 0.01 to 0.02 in. is sufficient. No slippage will occur unless the surface of the sphere should at some time be worn down so far as to allow the rollers that carry the ball-bearing shafts to roll up over the top of their supporting arcs, but that will never happen if the arcs are made of a sufficiently great length, no matter what wear might take place.

MR. CRAVENS:—How are that ball-bearing, its shaft and the two small rollers held in place?

MR. STURGES:—They are held in place by the spheres; just setting them in there holds them in place.

MR. CRAVENS:—How are the elements constructed?

MR. STURGES:—They are rollers having grooves in which the shaft of the ball bearing rests.

MR. CRAVENS:—What keeps them from sliding out lengthwise or at right angles to the curtain?

MR. STURGES:—A curved surface in the center of the rollers.

MR. CRAVENS:—What keeps the rollers from sliding lengthwise?

MR. STURGES:—Flanges in the mutor prevent any lengthwise motion of the rollers in the heavy-duty type in question, which is shown in Figs. 1 and 2.

J. H. HUNT:—I fail to understand why some twisting motion does not occur when following the curved path on the sphere. I have not a clear enough picture of what the development of the path of the ball bearing on the sphere would be, but it seems to me that it is not following the arc of a great circle. I think it would clear matters up to state what the efficiency of this transmission is when the reduction is say 2 to 1.

MR. STURGES:—Fig. 3 of the paper shows the path of the mutor bearings over the surface of the sphere. The bearing rolls up on a tangent with line-contact, comes to a stop and rolls down on another tangent, and the fact that it is a tangent proves the absence of any twisting or rubbing. The actual efficiency has never been determined by a dynamometer test. On direct drive, the efficiency excels that of a standard gear-transmission, as there is no loss except that due to the slight churning of the oil. On direct drive or in any other position we do not know the exact efficiency; but the fact that we can pass on a mountain road any other car of anywhere near the same horsepower, by accurately regulating the engine speed to give the maximum amount of power, speaks well for the efficiency. Further, the transmission does not become particularly hot in running up a 6-mile mountain road. A transmission that we have in a Dodge car has been in operation for 3 years without showing any appreciable signs of wear. As the power is all transmitted through ball bearings, the transmission must be very efficient.

PRESIDENT H. M. CRANE:—Of what material is the sphere made, and what is its finished condition as to hardness?

MR. STURGES:—It is a steel forging case-hardened on the inside and then ground.

CHAIRMAN ANGLADA:—What is the scleroscope test of the hardness or the Brinell hardness of the co-acting surfaces?

MR. STURGES:—That is a matter yet to be determined more completely. The present transmission-sphere was case-hardened and shows very little, if any, sign of wear after 3 years.

A MEMBER:—In using the engine as a brake, for fairly high speeds on a steep hill, is it necessary to change the position of the lever gradually and be careful not to get it clear to dead-center before the car is practically stopped?

MR. STURGES:—If the transmission were brought to dead-center instantaneously, the rear wheels would be locked. One would scarcely want to do that from a high rate of speed. On the Dodge automobile a crank must be turned completely around, and that prevents bringing the transmission to zero immediately.

O. P. LIEBREICH:—What is the diameter of the ground sphere?

MR. STURGES:—The type used in the Dodge automobile has a 10-in. interior-diameter ground-surface.

A MEMBER:—On what part of the transmission does the greatest strain fall, and what is the weakest link in it?

MR. STURGES:—On this particular type, it probably is the ball bearings. Inasmuch as we have standard outer-races ground down to an arc, they are thinner than the outer-races of the average ball-bearing. As I said, they should have a heavier outer than inner race. Several of the ball-bearing manufacturers have offered to supply bearings, at a slightly higher cost, that have a larger outer-race, thus providing ball bearings equally as strong as the rest of the transmission.

CHAIRMAN ANGLADA:—Does the mutor tend to creep on the sphere at high speeds or at any speed; that is, if the mutor were left unrestrained in one position and the engine were run and it propelled the car, would the mutor change its position?

MR. STURGES:—It would not because of the worm in the control.

CHAIRMAN ANGLADA:—If the worm were left off, would the mutor change its position?

MR. STURGES:—The mutor might change its position somewhat, but theoretically no reaction on the control due to the power transmitted occurs in this automobile type.

T. J. LITLE, JR.:—When I first saw this transmission, I was very much impressed with it. It is a really remarkable thing. The car on which it is installed can crawl along at 0.01 m.p.h.; one would not know it was moving.

STANDARDS OF HONESTY

THE standards of honesty, of a sense of mutual obligation and of service, were determined 2000 years ago. They may require at times to be recalled. And the responsibility for them increases infinitely in high places in either business or Government, for there rests the high responsibility for leadership in fineness of moral perception. Their failure is a blow at the repute of business and at confidence in Government itself.

American business needs a lifting purpose greater than the struggle of materialism. Nor can it lie in some evanescent, emotional, dramatic crusade. It lies in the higher pitch of economic life, in a finer regard for the rights of others, a stronger devotion to the obligations of citizenship that will assure an improved leadership in every community and in the Nation; it lies in the organization of the forces of our economic life so that they may produce happier individual lives, more secure in employment and comfort, wider in the possibilities of enjoyment of nature, larger in its opportunities of intellectual life. Our people have already shown a higher sense of responsibilities in these things than those of any other country. The ferment of organization for an increasingly definite accomplishment of these things that make for the greater welfare of the average citizen in the practical day-to-day progress of human life is alive in our business world.

The Government can best contribute through stimulation of and cooperation with voluntary forces in our National life; for we thus preserve the foundations upon which we have progressed so far, the initiative of our people. With vision and devotion these voluntary forces can accomplish more for America than any spread of the hand of Government.—Herbert Hoover.

Developments in Motorbus-Body Design

By HUGH G. BERSIE[1]

AUTOMOTIVE TRANSPORTATION MEETING PAPER *Illustrated with* PHOTOGRAPHS AND DIAGRAMS

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

CLASSES of service already provided by the street-car and the passenger automobile influence the expectations of the motorbus passenger regarding the quality of transportation service afforded by the motorbus. If an operator persuades people to ride in his motorbuses, it will be because they offer safety, economy, convenience and comfort to a greater degree than that offered by competitive transportation media. Since the public has demonstrated that, under favorable conditions, it will patronize the motorbus to an extent that yields a profit to the operators, the future success of this means of transportation lies wholly within the control of the motorbus builders and those who operate it. Of the factors that determine the degree of success attained, motorbus-body design bulks very large.

Discussion of the subject is presented from the viewpoint of the passenger, as the motorbus approaches him, as he enters it and as he judges the quality of transportation it affords. He gathers favorable impressions from the attractive general appearance of a motorbus, its low steps and floors, wide entrance-doors and aisles, ample head-room and knee-room, comfortable seats and effective ventilation, lighting and heating. Therefore, these divisions of the subject are treated with a view to specifying exactly what constitutes good practice for each, illustrations and tabular data being presented.

Greater safety and comfort for the passenger are the factors that will enlarge the scope of motorbus transportation. Such attainment depends upon the economic pressure brought to bear on those who supply materials for motorbus-body construction, and upon the motorbus-body builders who avail themselves of improved materials.

NOW that the motorbus has passed through the preliminary stages of development, it is evident that its future as a transportation medium is entirely in the hands of the builders and the operators. The public has demonstrated that, under favorable conditions, it is willing to patronize the motorbus in sufficient numbers and pay a fare such as will yield a profit to the operators. The passenger automobile and the street-car are manifestly its strongest competitors; consequently, their influence is keenly felt in motorbus-body design. If an operator persuades people to ride in his motorbuses, it will be because they offer safety, economy, convenience and comfort to a greater degree than do competitive transportation media. That is within the realm of possibility. Its realization depends on the cooperation of the body builder in making a thorough-going study of the motorbus.

What the motorbus passenger expects is influenced in some measure by the classes of service given by the antecedents of the motorbus; namely, the street-car and the passenger automobile. Each has had its influence in this development but, in the past, the passenger car probably has had the larger share. At present, however, the street-car type, or the pay-as-you-enter, motorbus is in the ascendency. This is shown by the returns tabulated by *Bus Transportation* for the year 1923. Briefly, these indicated that approximately 70 per cent of the new motorbuses placed in service during the year were of the street-car type. This by no means implies that the sedan or de-luxe type and the double-deck vehicle are passing. They will have their place, but it will be largely in boulevard or intercity service. The mass of motorbus transportation must be carried in the P. A. Y. E. type.

FIG. 1—STREAM LINE BUS BODY
Compound Curves Eliminate the Former Displeasing, Square-Cornered Boxlike Appearance and the Rounding of the Front and the Molding of the Dash and the Windshield into Pleasing Curves Have Also Contributed to an Attractive Appearance

STREET APPEARANCE OF MOTORBUSES

In determining the viewpoint of the passenger, we shall adopt the plan of considering the motorbus as it appears to him during its approach, as he enters it and as he judges the quality of transportation it affords him. The things that impress him favorably are an attractive general appearance, low steps and floors, wide entrance-doors and aisles, ample head-room and knee-room, comfortable seats, good riding-qualities and effective ventilation, lighting and heating. It is true that everyone is familiar in a general way with these requirements, but it is another thing to express them definitely in inches and feet or other exact terms as a measure of good practice.

An attractive, substantial, safe-looking motorbus appeals to the public; in contrast, a box-like construction would repel fares. That is well shown by the development of the streamline body and the use of attractive colors and finishes on the side-panels. The color trend is somewhat toward the brighter hues in place of the somber colors that were prevalent a year ago. Because the motorbus operates on a regular schedule, the bright colors that are required for the taxicab are not neces-

[1] M.S.A.E.—Engineer, Haskelite Mfg. Corporation, Chicago.

TABLE 1—DEVELOPMENT IN STREET-CAR TYPE, SINGLE-DECK, MOTORBUS-BODY DESIGN

Make of Motorbus	Height of Step Above the Street, In.	Height of Floor Above the Street, In.	Head-Room at the Center, In.	Center-to-Center Spacing of Seats, In.	Knee-Room, In.	Width of Seats, In.	Width of Aisle, In.	Entrance Door		Emergency-Door Location	Lighting		Ventilators		Material		
								Type	Width, In.		Number of Lamps	Cp.	Number	Type	Roof	Side Panels	Headlining and Sidelining
Yellow Coach	13⅜	26⅜	77	29½	....	32	19	Jacknife	....	Left Rear	10	21	....	Louver	Slats	No. 14 Gage Aluminum	Haskelite
Twin City	15	24	72	31	....	34, 35	....	Two Doors	28, 31	Left of Driver	6	....	5	Perfection	Slats	Plymetl	Birch
Royal Coach	14½	25½	76	....	10	34	16	Inward Folding	....	Left Rear	8	21	....	Nichols Lintern	Composition	Plymetl	Veneer
Eckland	16½	32	64	30	....	34	15	Double Swinging	28	Left Front	6	....	....	Monitor	Haskelite	Fabric-Covered Board	Optional
Moreland	13	24	72	28	....	34	18	Folding	30	Left Rear	10	12	2	....	Haskelite	Plymetl	....
Kastory	17	30	72	29	....	....	15	Double Folding	28	Left Rear	7[a]	....	....	Nichols Lintern	Slats	Plymetl	Haskelite
Schaefer	17	34	75	30	....	34	13[b]	Center Divided	27	Rear End	6	21	....	Nichols Lintern	Slats	Aluminum	Steel Side-lining
Whitfield	14 to 15	28 to 31	70 to 74	30	....	32	14	Double Leaf	30	Left Rear	6	21	....	Nichols Lintern	Haskelite	Fabric-Covered Steel	None
Wier Co	14	....	74	....	13½	32	16	Folding	24	Left Rear	8	4	....	....	Slats	Plymetl	Haskelite
Fageol	15	22	72	....	14	32	15	Folding	29	Left of Driver	8	4	....	Nichols Lintern	Slats	Metal	Fabrikoid
Fremont	15	....	74	32	....	34	16	Folding	32	Left Rear	12	4	....	Nichols Lintern	Slats	Plymetl	Fabrikoid Trimmed
Weatherproof	9 to 15	20 to 26	74	31	....	32	17	Folding	27¾	Rear End	5	....	2	Nichols Lintern	Slats	Steel	Haskelite
International Motor	18¼	27⅜	73¼	....	8	33¼	17	Folding	26	Left Rear	6	21	3	Nichols Lintern	Haskelite	No. 14 Gage Aluminum	....
Wentworth & Irwin	16	30	75	....	15	34	16	Folding	24	Rear End	7	8	3	....	Wire	Steel	....
Schubert	13	26	70 to 76	29 to 35	....	32 to 35	17[b]	Folding	28	Rear End	6	21	3	Nichols Lintern	Plywood	Aluminum	....
Lang	17	30	74	27 to 30	....	32	14½	Folding	30	Left Rear	6	21	3	....	Slats	Aluminum	Steel Side-lining
Kuhlman	16	29	75	....	11	33	18	Folding	29	Left Rear	7	21	3	Nichols Lintern	Haskelite	Plymetl	None

[a] Reflectors 6 in. in diameter are used with these lamps.
[b] This dimension is taken at the level of the seat cushion.

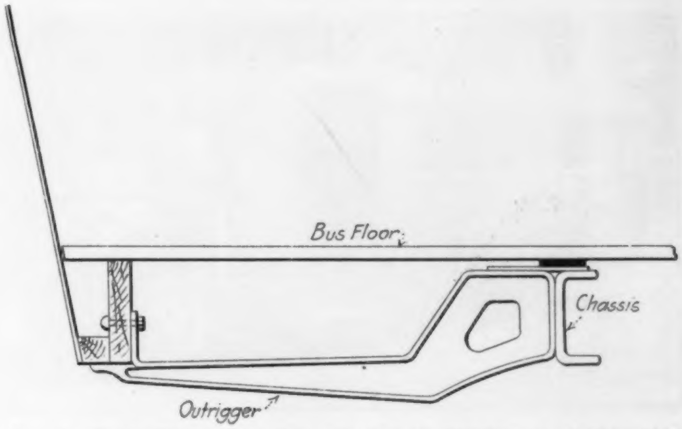


FIG. 2—CROSS-SECTION OF BUS CHASSIS IN WHICH AN EFFORT HAS BEEN MADE TO REDUCE THE FLOOR HEIGHT
The Much To Be Desired End Has Been Obtained by Resting the Floor Directly on the Frame Channels

sary; however, certain shades of dark brown, red, green or blue are admirably suited to motorbus requirements. An excellent arrangement of the Chicago Motor Coach Co. is the use of distinguishing colors for motorbuses serving different sections of the city; brown for the North, green for the West and red for the South sides.

Attractive automobile finishes, as well as color, are an asset. Here the automobile field, rather than that of the street-car, has supplied special methods and materials. Metal has largely supplanted wood for the side-panels. Sand-blasting and "pickling" of the steel help to give a "tooth" for the finish. Metal has always had the defect of being easily dented, but this has been overcome by using a sheet of metal cemented to a nonmetallic structural back.

The securing of streamline effects by compound curvatures eliminates the displeasing square-cornered, box-like appearance. The rounding of the front and the molding of the windshield and dash into pleasing curves have been worthwhile efforts. These results are well shown in the accompanying illustrations. Fig. 1 illustrates this effect obtained in the P. A. Y. E. type.

Decrease in the amount of overhang has resulted from the development of a number of heavy-duty chassis of 190-in. wheelbase or longer. Overhangs that were tolerated a year ago are not considered seriously now. All these factors have a bearing on the general appearance of a motorbus.

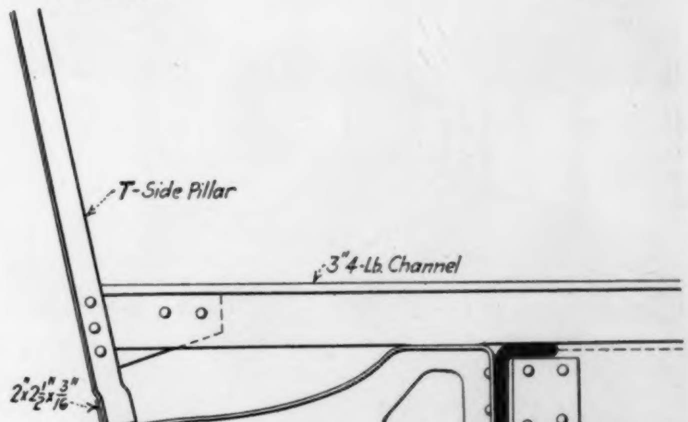


FIG. 3—ANOTHER FORM OF CHASSIS CONSTRUCTION
In This Design the Floor Rests upon a 3-In. Channel That in Turn Rests upon the Side Channel of the Frame and the Side Sills Are Supported on Outriggers Bolted to the Frame

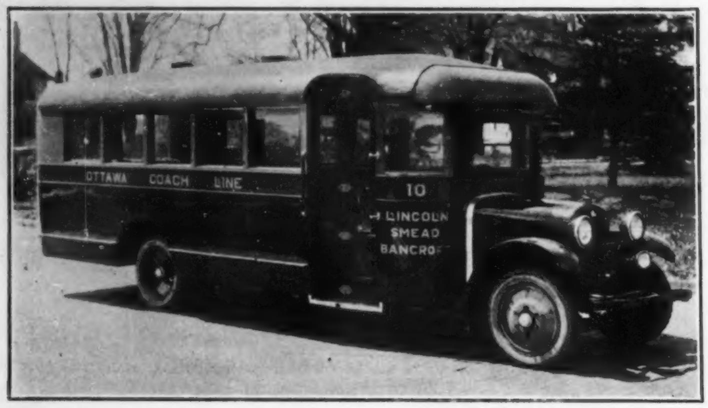


FIG. 4—THE MAXIMUM AMOUNT OF HEAD-ROOM IS DESIRABLE AT THE ENTRANCE AS WELL AS INSIDE
One Way of Attaining This End Is Cutting-Out the Roof at the Entrance Door

ENTRANCE DOOR AND STEP

As a passenger starts to enter a motorbus, his first impression is that of the step height. A low step and a low floor not only affect profits by attracting fares, but also by decreasing the time required for passengers to enter and to leave. As a typical cross-section of current practice, data are listed which were reported in a questionnaire sent to leading builders. Table 1 shows a step height of from 13 to 18 in. This compares favorably with the height of the street-car step, which averages about 14 in. above the rails. Theoretically, at least, the motorbus is supposed to load directly from the curb, which is between 4 and 12 in. above the street level. The elevation of the motorbus floor ranges from 22 to 32 in. Recent efforts of chassis manufacturers have done much to reduce floor heights. The heavy-duty 190-in.-wheel-base chassis have an elevation of from 25 to 30 in. above the street level. While the kick-up frame construction is expensive, it is worthwhile from the standpoint of lower floor-levels. By resting the floor directly on the chassis frame, except for an intermediate layer for shock deadening, and using outriggers to support the side-sills, a reduction in level can be obtained. Figs. 2 and 3, showing cross-sections of the motorbuses built for Stone and Webster and for the Public Service Electric & Gas Co. of New Jersey, typify this construction.[2]

[2] See *Bus Transportation*, April, 1924, p. 165; and July, 1924, p. 299.

FIG. 5—INTERIOR OF THE LOWER DECK OF A DOUBLE-DECK BUS
The Use of Supporting Stanchions and a ⅝-In. One-Piece Roof Has Made Possible the Elimination of All Cross Bows and Ribs and Increased the Head-Room by 2 or 3 In. Aside from Clearing Up the Ceiling, the Bus Interior Is More Attractive and Is Kept Clean and Sanitary More Easily

FLOOR CONSTRUCTION

Maple is the favored wood for flooring; in the questionnaire, it leads the other woods by 50 per cent. Among oak, pine and fir the vote was equally divided; ash and poplar each received one vote. Thicknesses ranged from ⅞ to 1¼ in. Two well-defined floor constructions seem to exist. When cross-sills about 2½ in. deep are employed, ⅞-in. flooring is laid with the grain running lengthwise of the body. These cross-sills are spaced 18 to 24 in. apart. When the cross-sills are eliminated, 1⅛ to 1¼-in. flooring is laid directly on the two longitudinal sills or frame channels, but with the grain of the flooring running across the body. These longitudinal sills are about 75 in. apart and, of course, the floor extends nearly 15 in. beyond on each side. This is a rather thick and heavy floor and might be reduced to ⅝ in. by the adoption of structural plywood flooring carried by the longitudinal sills and by cross-sills spaced 5 ft. apart. Tests have shown that, with square panels supported at all edges, the plywood is approximately 52 per cent stiffer than plain tongue-and-groove lumber of the same thickness. This points the way to lower floor-

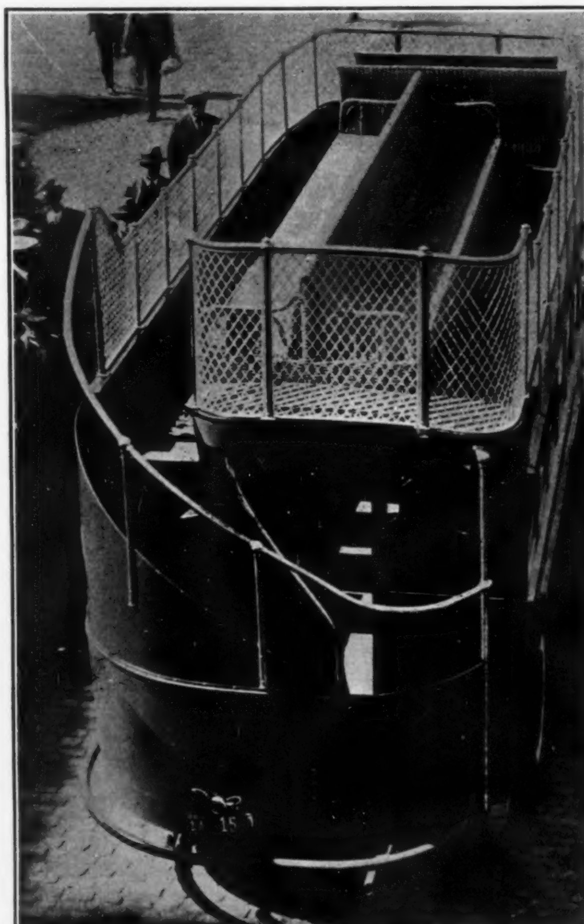


FIG. 6—ANOTHER METHOD OF SECURING AMPLE HEAD-ROOM
A Double Row of Longitudinal Seats Placed Back to Back in the Center of the Upper Deck Increases the Head-Room in the Aisle of the Lower Deck

FIG. 7—LOWER DECK OF THE BUS SHOWN IN FIG. 6
Note How Ceiling above the Aisle Is Much Higher than over the Seats as a Result of the Use of Longitudinal Seats on the Upper Deck

levels. These floor boards can be furnished in one piece.

Efforts are directed toward making floors more gas-tight. One builder lays ⅛-in. paper felt on the floor and then covers this with No. 26 cotton duck; over the latter, 3/16-in. linoleum is placed. Another manufacturer packs asbestos around heater openings to assure a gas-tight joint. Practically 90 per cent of the builders answering the questionnaire reported that they used linoleum as top covering, but a few employed rubber matting.

The width of the service door calls for its measure of attention, because of its effect on the speed of loading and unloading the motorbus. Current practice runs largely to the folding jack-knife type, from 28 to 30 in. wide. However, a need exists of reducing the time of loading further. Of what value is rapid acceleration and a greater speed if the time thus gained is lost at the loading points? And, taking the wages of the platform men into consideration, a tendency exists toward higher speed as being more economical. Greater loading-speed will accomplish the same result.

Table 1 shows that the favored location for the emergency door is on the left side at the rear. Control of the door is from the driver's seat or by a glass-concealed control at the rear. The driver's control may be by a No. 20 gage piano-wire protected by a 3/16-in. brass tube.

HEAD-ROOM AND KNEE-ROOM

Were we a race of short stature, as are the French people, the problem of head-room and knee-room would not be so serious as it is. Table 1 shows a head-room ranging from 64 to 76 in. at the center of the motorbus. I have not much sympathy with anything less than 75 in., but 72 in. is about the average head-room. Premising a low-slung body, it is difficult to increase the head-room materially; but every inch counts and the difference between 72 and 75 in. may account for several thousand fares a year. One way of gaining additional head-room at the entrance is shown in Fig. 4.

With the use of supporting stanchions and a ⅝-in. structural plywood roof made in a single piece, the Yellow Coach Mfg. Co. has been able to eliminate all cross bows and ribs in its Type *Z* double-deck coach. This increases the head-room 2 to 3 in. From this standpoint alone it is worthwhile, but an added advantage is that it clears up the ceiling, making it more attractive and more easily kept clean and sanitary. This is well shown in Fig. 5. Three stanchions have been found sufficient for the support of the roof. The crown or camber is transverse and amounts, approximately, to 6 in. The panels are designed so as to possess their maximum strength and stiffness crosswise of the motorbus. Before this type of roof construction was adopted, motorbuses were tested with static and impact loadings, and the results are stated in Table 2.

Another method of gaining additional head-room in the lower part of a double-deck motorcoach is illustrated in Figs. 6 and 7. In this type of construction a double row of longitudinal seats placed back-to-back in the center of the upper deck, as illustrated in Fig. 6, provides ample head-room in the aisle of the lower deck, as is clearly shown in Fig. 7.

AISLE AND SEAT WIDTHS

Proceeding with the passenger who has entered the motorbus, its seats come in for consideration. Table 1 shows an aisle width of from 13 to 19 in. and a seat width of from 32 to 35 in. The spacing of seats ranges from 28 to 31 in. That spacing provides a distance of between 10 and 11 in. from the front of one seat to the

FIG. 8—VIEW OF A DOUBLE-DECK BUS WITH PLYMETL PANELS IN THE COURSE OF CONSTRUCTION
The Double Cut-Outs for a Six-Wheel Chassis Is an Interesting Feature

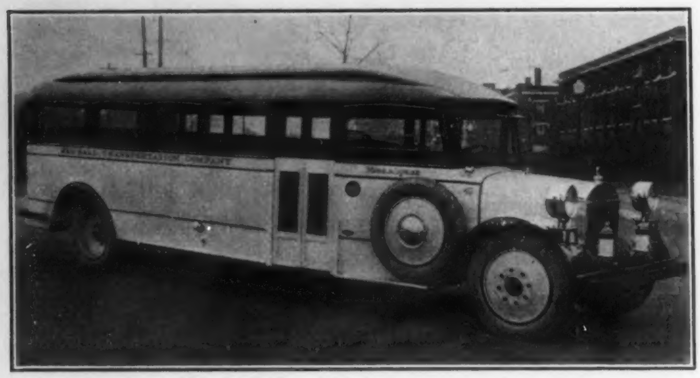


FIG. 9—AN EXAMPLE OF THE MONITOR-DECK TYPE OF BUS
The Chief Features of This Design Are Effective Ventilation and Ample Head-Room

back of the next; and is called "knee-room." Additional space is sometimes gained by the recessing of the seat-backs. This is an excellent plan, and I imagine that all seat manufacturers will soon put out a seat of this kind. At least 1½ in. can be gained by the recessing. A person cannot be expected to patronize a motorbus consistently unless he is seated comfortably. To gain effective aisle width, at least one builder has adopted the plan of extending the arm-rests on the aisle side of the seat somewhat beyond the seat-back. For example, the Schaefer Wagon Co. reports that the width of the aisle is 13 in. at the cushion, but 16½ in. at the height of the seat-back.

RIDING-QUALITIES

After the passenger is seated a ride, pleasant or otherwise, is before him, dependent on the riding-qualities of the motorbus and the provisions for safety, ventilation, lighting and heating. It is well known that a short overhang makes for safety and comfortable riding and, for that reason, chassis are being made longer than they were made a year ago. Safety, being of prime importance, comes in for first consideration. I am afraid that little can be learned from passenger-car construction, although the sturdiness built into the taxicab body points the way to lighter and more durable materials, some of which are employed in airplanes. Taxicab

FIG. 10—AN EXAMPLE OF EXCELLENT BUS LIGHTING
The Lighting Arrangements of This Bus Were Worked Out by the Builder in Conjunction with Illuminating Experts. Side Lights and the Reflecting Surface of the Enameled Ceiling Provide the Illumination. The Egg-Shell Finish in This Particular Case Is Applied Directly to the Concave Interior Surface of the Roof, No Headlining Being Used

builders favor the use of the tough, non-splintering ash for framing, rather than maple which, though stronger, breaks with a long fracture. The airplane material mentioned is the structural plywood panelling that is molded into fuselages and wing-beams. The same kind of panels are used for cab and street-car roofs and, naturally, their strength adds to the factor of safety. Operators have pointed out the difference between their behavior and that of wooden slats in case of severe accident. The latter, of course, produce long jagged fractures dangerous to life and limb; but the panels, difficult to damage in the first place, break with short blunt edges. This discussion applies primarily to overturns. In case of the more common sideswipe or collision, the same material for panelling, but faced with steel and termed Plymetl, absorbs the energy of the impact. The result is that, in most cases, damage to frame-work or passengers is prevented. A view of a motorbus covered with this material is given in Fig. 8.

Recently, we heard of an accident in Akron, Ohio, in which a motorbus constructed with these materials had

TABLE 2—IMPACT AND STATIC-LOAD TESTS MADE ON HASKELITE MOTORBUS ROOFS[3]

Impact Tests[4]				Static-Load Tests[5]				
Number of Supporting Stanchions	Deflections, In.			Observation Point	Static Load, Lb.			
	Vertical	Horizontal	Diagonal		800	1,600	2,400	3,200
					Vertical Deflection Under Load, In.			
3	1/32 [c]	1/16	1/8	1	1/16	3/32	5/32	7/32
1	1/16	3/32	1/8	2	1/8	7/32	[illegible]	[illegible]
0	1/16	1/8	1/8	3	3/32	17/64	[illegible]	[illegible]
....	....	....	....	4	1/8	11/64	11/64	..

[3] Roof Construction: A panel of ⅝-in. three-ply Haskelite over the entire floor-space of the upper deck of a 67-passenger Yellow Cab Co. motorcoach, reinforced by a 2-ft. strip of ⅞-in. boards running down the aisle space. Roof Support: Front and rear supports by bulkheads and by stanchions.

[4] The impact tests were made while the motorbus was running, not loaded, on city streets.

[5] The static-load tests were made while sand-bags were loaded uniformly in the aisle. Observation points were selected at equi-distant spaces from the driver's cab to the rear. Point No. 3 should show the maximum deflection, as it approximately represents the center of the beam.

[c] This measurement is that of the combined deflection of the floor and the roof.

a serious encounter with a street-car. The street-car was badly damaged but the motorbus was harmed but little. That shows the progress of the builder along the line of safety. Incidentally this was an all-steel-frame motorbus built by a street-car plant.

WARMING, VENTILATING AND LIGHTING

In connection with the motorbus, we speak of "warming" and not of "heating." Perhaps nothing more than warming is needed. Almost all the heaters are now of the exhaust type, but a few employ hot water. The practice is to make use of thin-walled pipes of about 2-in. diameter, which are fitted with protective guards. If someone would corrugate these pipes or construct them with internal and external fins, the flow of heat from them would be increased.

Since it is not feasible to use a more effective means of heating, it is necessary to construct the motorbus so that it is heat-insulating. Next in importance to the unavoidable loss through the window glass, is the heat waste through the roof. The heated air inside the motorbus naturally rises; the result is that the greatest

temperature-difference between the inside and the outside air is at the roof, and hence the heat-flow there is the greatest. This fact calls for a roof that is a good heat-insulator. The heat loss by no means is confined to the roof; a loss through the floor and the sides exists;

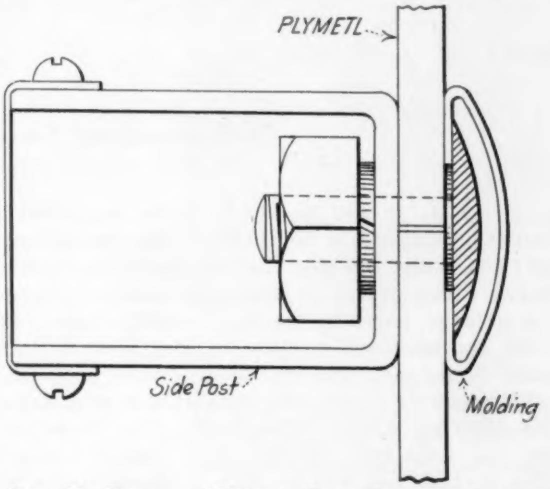


FIG. 11—TYPE OF MOLDING USED TO ATTACH SIDE PANELS
The Bolt Heads Are Concealed by the Molding, but the Panels Are Readily Removable in Case of Accident for Replacement

the latter can be stopped by insulating materials. When metal sides are used, an insulating lining is needed; but this, of course, is not required with Plymetl.

It would be hard to beat the old monitor-deck street-car for good ventilation, but it is passing with the advent of the turtleback or arch type of roof. It is interesting to note that at least one motorbus-body builder provided a monitor-decked motorbus, as shown in Fig. 9. Both street-cars and motorbuses have secured good air-circulation with ventilators installed in the arch-type roof. Lately, the tendency has been toward the adoption of small ventilators just above the windows. These are called louvers. They are much better than no ventilators; but, in my opinion, room for improvement exists. Window sash is showing commendable improvement. In past years windows always rattled or stuck, or did both, with the uncontrollable obstinacy that sometimes possesses inanimate objects. The brass or metal sash is a vast improvement over the wood.

It is gratifying to note the development in the illumination of motorbuses. Lights of 21 cp. are the rule now. Sharing importance with the number and the size

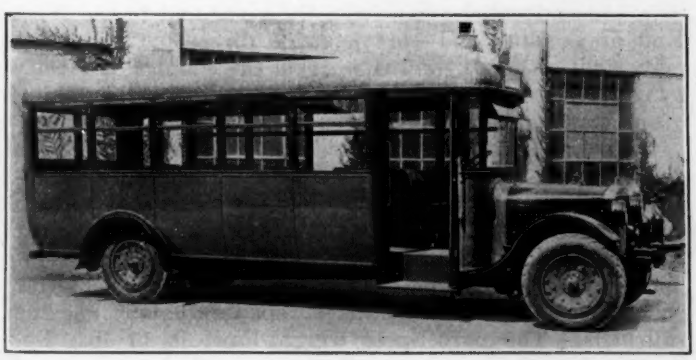


FIG. 12—AN EXAMPLE OF A MOTORBUS IN WHICH THE SIDE PANELS ARE ATTACHED BY THE TYPE OF MOLDING SHOWN IN FIG. 11
Even Though Very High-Grade Materials Are Used, Severe Accidents May Require the Replacement of Windows, Panels and Similar Body Parts. The Use of This Type of Molding Makes Removal and Replacement a Comparatively Simple Matter

of lights is the kind of reflecting surface afforded by the ceiling. Some have adopted an egg-shell finish of either white or cream. I understand that the G. C. Kuhlmann Car Co. has had the assistance of the Nela Park engineers in developing its motorbus lighting facilities. An interior of this company's motorbus equipped with the enameled structural plywood ceiling is shown in Fig. 10. Incidentally, this finish is applied directly to the concave or interior surface of the roof. No headlining is used. Some builders supply only grab-handles on the seats or overhead rails, but most of them supply both for safety's sake.

Now that the operator has transported his passenger satisfactorily, it remains only to be seen whether or not the motorbus-body helps to make it a profitable operation. To do this the body must stand up well in the hard daily grind, with but small maintenance expense. That involves the use of the best type of framing, with well-made joints that prevent it from soon becoming noisy and rickety. So far as possible, body parts are to be made easily replaceable. Particularly is this true of windows, panels and the like. Even when the very best materials are used, severe accidents may require their replacement. Side-panels, attached by bolts whose heads are concealed by molding, as shown in Fig. 11, can be removed easily and replaced with new panels. An example of this method is shown in Fig. 12.

STANDARDIZATION

I consider it a duty to say a few words about unification, commonly called standardization. Reverting to the

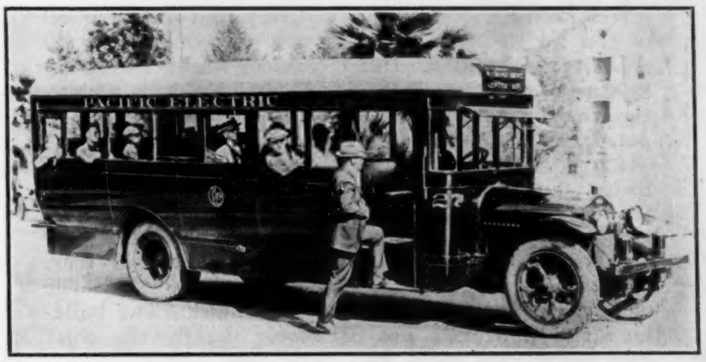


FIG. 13—A BUS USED ON THE PACIFIC COAST
In This Design Glass Windows Have Been Replaced by Rolling Curtains. The Rounded Windshield and the Use of Sectional Metal Side Panels Should Be Noticed

antecedents of the motorbus, the street-car and the passenger automobile, we find almost complete standardization of the automobile, and a more or less futile attempt to standardize the street-car industry. Without doubt a need exists for different types of body in various sections of the Country. For instance, in the West and the South, glass windows can be dispensed with and roll-curtains used instead. This type of equipment is shown in Fig. 13. But most assuredly certain basic designs, shapes and measurements might be unified, with benefits accruing from such standardization. Economy of construction and easy replaceability of parts have been well recognized in the manufacture of chassis and, eventually, we predict, will have due recognition in body plants.

Standardization in one's own plant at least might be worked out so that stock parts will be on hand to reduce production costs and speed delivery. It is only a ques-

(*Concluded on p. 358*)

Small-Consignment Commodity-Distribution in London and Its Environs

By James Paterson[1]

Automotive Transportation Meeting Paper *Illustrated with* Drawings

ABSTRACT

POINTING out that London is the social and economic center of the British Empire and describing its port, its transportation needs and facilities and those of its environs, the author traces commodity movement from ships to lighters and to warehouses, from warehouses to stores, from stores to homes, to the surrounding towns and to country districts, and gives details of the distribution and collection system developed and operated by the company he represents, a system employing horse-drawn and motor-vehicle equipment that traverses the streets and the highways. Major divisions of the details presented include statements regarding the nature and weight of packages, segregation of the territory into districts, sorting depots and transfer thence to delivery depots, direct deliveries, store-door delivery and the time required for delivery. The service offered by the railroads is also treated. Other features mentioned briefly relate to statistics of the street and highway service, the various zones, the charges, clerical methods and personnel.

Plant equipment includes horses, horse-drawn vehicles, and gasoline-driven and electrically driven trucks. The gasoline-driven transfer-trucks have detachable bodies, as have the trailer trucks that are operated with them. The electric trucks and their service receive consideration, and the types of vehicle most needed for the future are outlined. The buildings and platforms are of simple design, the chief need being yard space well paved and fenced.

A feature of the service that is emphasized relates to the careful selection of the employes, based on considerations of character and probity, and their subsequent training while employed. Reference is made to the very limited duties that the horse will perform when the conversions from horse-drawn to mechanical transport now contemplated are made, and advice concerning how far such conversion should proceed is solicited.

LONDON is the chief city of a group of States that are united under one ruler, but separated from each other by the Seven Seas. They have a total population of about 450,000,000 and the great ocean trunk-lines connecting them are traversed by ships. The relationship between the States is like that of members of a good club, and London can be said to be located at the geographical center of this club.

Fig. 1 shows London and its environs. The River Thames is uncrossed by bridges below the center of London, but two road-tunnels and one rail-tunnel under the river are located below the center of the city. The country is mainly free from transportation obstacles; much of it is from 300 to 600 ft. above sea level and it is beautiful, fertile and healthful. The prevailing wind is a soft southwest one and there is but little frost or hot weather. Clean water is available almost everywhere and, in a large portion, gas and electric light. Therefore, the southeastern portion of England is becoming a garden homeland, and the distribution problem is to meet the needs of 12,000,000 inhabitants who occupy an area of 4000 sq. miles. Those who live 30 miles from London can come into the city daily; those living up to 70 miles distant can easily visit it three times weekly. As shown in Fig. 2, the coast is studded with seaside resorts, and many of them are frequented in winter as well as in summer.

The inhabitants are nearly all of British stock; those who are not tend to live together in the center of London. The English people are inclined to trust any man until he is proved dishonest, are tolerant, slow to anger and fond of their homes, gardens and parks. They are skeptical of any article or man that is over-advertised and think a person who talks much must have a bad cause to plead. They hate being hurried and dislike compulsion of any kind, including military service and such things as the filling-in of forms. They like a seaside holiday each year, but they are prone to indigestion because of eating white flour and preserved food and are short of sunshine and electric power.

Distribution

Regarding what distribution arrangements the people inhabiting these 4000 sq. miles of territory require, the first movement of commodities is from ships to warehouses. When ships were smaller, more could come up to London Bridge and great warehouses were built there and also above the bridge; but, at present, much traffic is conveyed by lighters from the docks to those warehouses, more than 12,000 lighters being in use on the River Thames. Part of the movement is by road to warehouses located away from the river and to the West End of London, and part is made direct by rail. The movement of goods coming in from the country is mostly by rail; some, such as fruit, milk and the like being often transported over the roads.

Bulk distribution from warehouses to retail stores is generally by road within a distance of 15 miles, gradually changing to rail as the distance increases; certain traffic such as meat and the like are transported over the roads up to a distance of 75 miles. The removal of household goods is mainly over the roads. The letter post, the parcel post and the newspapers chiefly use the railroads. The parcel-post weight-limit is 11 lb. Delivery of goods by the retail stores to their customers' homes is made over the roads. Retail stores think more of quick service and of the advertising value of using their own trucks than of the commercial cost, which is generally great.

[1] Director, Carter, Paterson & Co., Ltd., London, England.

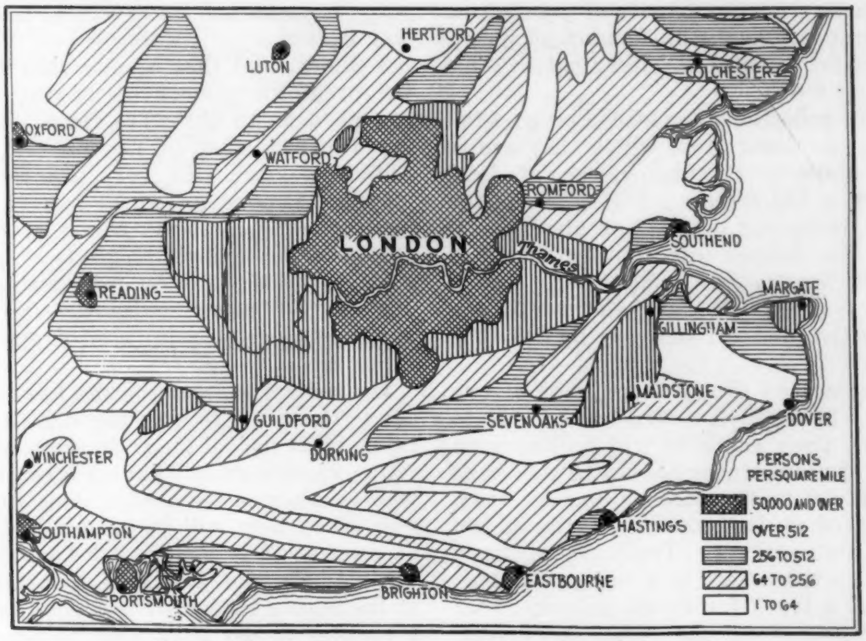


FIG. 1—MAP OF LONDON AND THE SURROUNDING COUNTRY
The Area Shown in the Map Has a Population of Over 12,000,000. The Density of Population Is Indicated by the Various Forms of Cross-Hatching

The service I shall describe in detail is over the roads to a large part of the territory shown in Fig. 1, and deals with small consignments to all sorts of people, to and from wholesale houses, stores and homes. About 40 per cent of the packages weigh less than 15 lb.; 20 per cent, from 15 to 30 lb.; and 40 per cent, more than 30 lb. A few weigh more than 200 lb. The consignments consist largely of one package only. About 42 per cent of them contain food, groceries and tobacco; 33 per cent, clothing; and 6 per cent, private luggage. Traders' goods and parcels of all sorts constitute the remaining 19 per cent.

THE DISTRIBUTION SYSTEM

Each driver is assigned a district. He delivers all that comes to him for delivery within that district, and collects all he can find to collect, giving a receipt if requested. He gives cards to his customers, who hang them in their windows to call him as he passes; and he has regular times at which to call on those who need him daily. He takes his truck out each morning from a depot, where he is given his load of deliveries, and he comes in once or more at fixed hours during the day to drop his collections and take out more deliveries. The

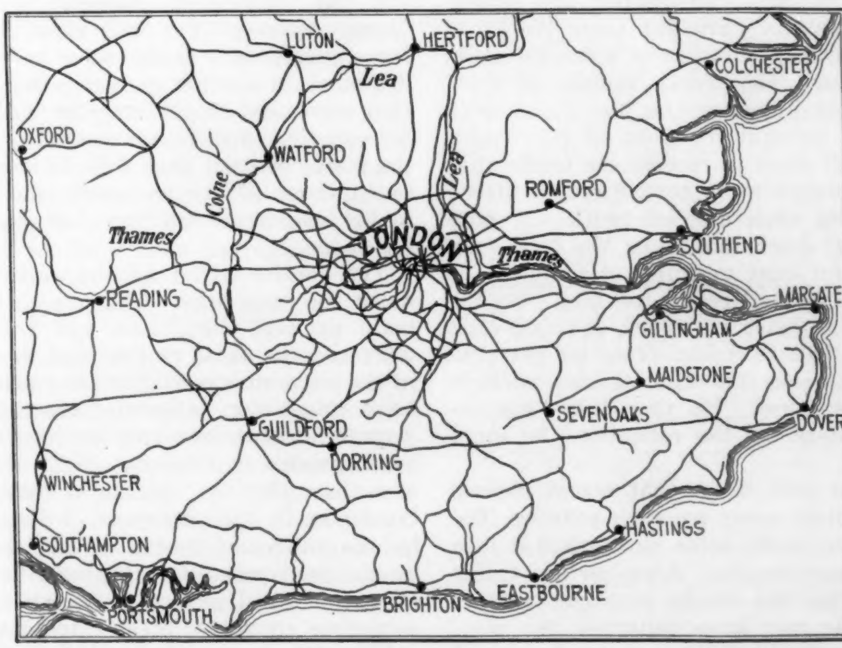


FIG. 2—THE SAME AREA OF 4000 SQ. MILES AS SHOWN IN FIG. 1 WITH THE RAILROAD LINES MARKED
This Whole Section of England Is a Large Garden Homeland. To Serve the 12,000,000 People Residing in This Territory the Railroads Have 1460 Stations, Thus Making It Possible for Those Living within a 30-Mile Radius of London To Come to the City Every Day for Business, While Those Dwelling Not More than 70 Miles Out Can Come in Easily Three Times a Week

size of his district varies with the density of population. It may be only one large warehouse in London, or ½ sq. mile in some town or 5 sq. miles of territory out in some country district.

At the sorting depot, collections are loaded on to 4-ton trucks for transfer to the depot from which they are to be delivered; this entails a fair knowledge of local geography on the part of the sorters. Fig. 3 shows the roads over which the trucks run. Each operates according to a time-table. The drivers leave at the scheduled hour, whether the vehicles are full or are partly loaded only. Fig. 3 shows also the clearing stations where mixed loads are re-sorted, and the delivery depots they pass through or end at.

The service is organized so that a large part of one morning's collections will catch transfer trucks due to arrive at depots; thus, their contents will be delivered the same day, and all the remainder should be delivered the next morning. Special traffic, such as luggage from ships or schools, is picked up in 4-ton trucks direct, and part is delivered without sorting. Traffic from many sources, but all going to one street in a town, would go from a sorting depot in a truck for direct delivery; that is, it would not be delivered by the "district" driver. An example of this is that of clothing from many London warehouses but all destined for sale by one retail store in some such town as Croydon. Skill is needed to fix the size of the districts, to specify the times set forth in the time-table, to decide whether loads are to go direct or through a clearing station, and to organize the transfer trucks so as to have a good load each way.

Small Consignments

Certain members of my audience are especially interested in the problem that a manager whose duty it is to organize deliveries over the roads of small consignments that come to him, whether from road trucks or from rail cars, must solve. We may look at this in detail, although I fear some of it may be commonplace; but a carrier conducts a primitive trade and his art is to do simple things exactly, punctually, regularly and safely.

After the district men have brought their trucks to the depot platform in the evening, have unloaded their collections and gone home, the trucks remain in their places, empty. The roller shutters on the front edge of the platform should be shut for most of its length, but part of them are left open to receive the traffic that is to arrive. This is sorted as it comes and is placed on the platform opposite each district truck. A note is made on the delivery sheet and, when the load each district-man will take out next morning is complete, it stands there all entered up and ready for him. On his arrival in the morning he loads his truck, stowing each consignment so that it can be taken from its place in the order in which he works his district and without disturbing the other packages. He then takes his delivery sheet and his orders for the collections he must make and drives out.

Some traffic comes to each depot that would swamp certain ones of the district men; so, each evening, the platform chief turns such traffic aside and makes it into loads for "special" delivery-trucks. Also, certain traffic can be loaded directly into the trucks at night to clear the platform. When the men have departed, the platform chief should see a platform clear of goods, except for one or two loads that his special trucks will be coming in for about 11:00 a. m. after having finished a short trip. In some cases the delivery men are told to call while on the road at some office or to telephone; in this way, they can receive orders to make collections on their way back.

I understand that at our railroad terminals, some of the preliminary work of making up loads for delivery can be done in the office from the delivery sheets. At one railroad office in London and at one chocolate-distributing depot, this work is aided by the use of small maps of London on which can be marked the routes a man should follow, the points at which he should make calls and the amount of goods at each. In one railroad office, detailed statistics were obtained with a tabulating machine of truck mileage, size of loads and time taken. Such statistics need supplementing by practical experience.

If "central control" means having one manager in an office who tries to run the details of several depots, I think it is not so likely to succeed as when each depot "runs its own show," having a central figure in command who watches to see that it does so efficiently, who foresees when help will be needed and who sends that help as soon as it is wanted. I have heard people advocate the obtaining of statistics regarding trucks that stand at the depots loaded with goods that await delivery; but I venture to say that what is wanted is to deliver the goods and so save the statistics. The governing principles are that the shorter time one keeps a thing, the less is the likelihood of breaking it; more haste may mean less speed; the lowest cost is obtained by having a full vehicle and goods should be re-sorted only if that is cheaper than not doing so.

Fig. 4 shows the traffic curve. I hope to learn something here of how to induce traffic to flatten such curves and of how to make repairs to trucks during the traffic cessations only. We have furthered this by building up a public-garage business that also repairs other people's vehicles; thus, we have a large repairs staff to make us able to meet our own seasonal needs more easily.

Railroad Service

I have shown that the road service is not only what you call "store-door delivery" for merchants, but also "home delivery" for individuals. We feel it essential for a carrier who is intrusted with goods that are to be delivered to another person after a certain transportation movement to perform the entire movement himself. He can thus inspire the confidence of both parties that the goods will not pass out of his men's hands until they reach those of the recipient; nor will they be delayed in his warehouse waiting for some third person to do his share.

The service given by the railroads is carried on in much the same way. The parcels are handed to a fast-train package-truck man, are transported by rail and delivered the same or the next day. Goods are handled in the same manner. For the reasons I described at the beginning, our railroads are not great trunk-lines. Except for coal, iron and the like, the average weight of consignments is, I believe, about 350 lb., and many weigh less than 150 lb. Packages handed to the rail-goods truckmen in the afternoon will generally be delivered by the railroads' trucks in any town within 250 miles by the next morning. Delivery trucks are available in all except small places in which the deliveries are not numerous enough to make a truck pay.

When the railroads built their terminals in London, the need for connecting lines north and south of the Thames was not sufficiently foreseen. For this reason, traffic collected by a railroad often requires longer for delivery than has been described, if it has to go around

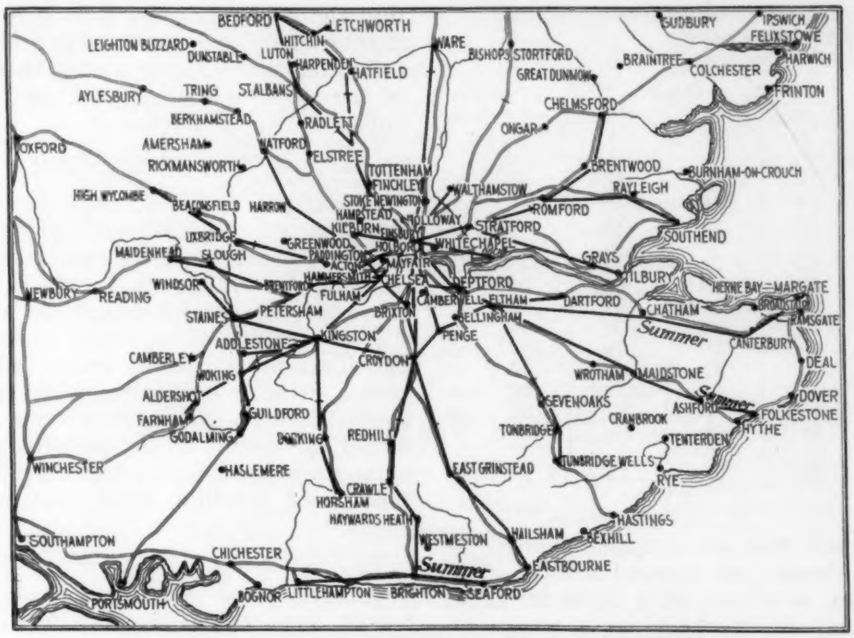


FIG. 3—MOTOR-TRUCK ROUTES SERVING SOUTHEASTERN ENGLAND

These Motor Trucks Run on Fixed Schedules, Leaving the Various Towns at Definite Times, Irrespective of Whether They Are Fully or Only Partially Loaded. This Makes It Possible for Goods Collected in the Morning of One Day To Catch Transfer Trucks at the Various Depots and Be Delivered the Same Day or the Next Morning at the Latest. Certain Depot Boundaries Are Shown by the Lines Crossing the Roads over Which the Trucks Operate

London and be handed to another railroad for delivery on the other side of the River Thames.

Our distributing agents have many customers who ask them to send one truck to collect all they have to send away, whether by road or by rail, the reason being that one truck only takes up less room at the door. They sort the goods and send the railroad portion off consigned to their agent in the other town; he collects from the railroad and delivers the goods. The reason is that, in some cases, this method is more convenient. It is not that it is quicker than the railroad service; it is of equal speed.

Many of our railroad rates for goods include charges for collection and delivery. No definite charge is published for these two road parts of the journey, but a rebate is allowed by the railroad if the road work is done by someone else. The arrangement in the case of passenger-train packages is different. There has been litigation in the past over these points. Anyone interested in this subject might study our experience of it and avoid the troubles we have been through, some of which still cause misunderstandings.

FURTHER DETAILS OF ROAD SERVICE

The amount paid to owners for loss or damage in 1923 was $1 per 1000 packages carried, the risk being usually limited to $50 per package. The amount paid for damage to other people in street accidents was about $5 per truck, and to members of the staff for accidents, less than $1 each. I do not know whether these figures seem good to you. I have come to learn to make them better.

Fig. 5 shows the principal towns within the area under consideration, and a number that designates the zone in which it is classed. Table 1 shows the prices charged, which vary with the zones.

With reference to Table 1, the following explanatory notes are needed: (*a*) the rates apply from the center of London to the different zones and are for road service; (*b*) collection is made one day and delivery the next, except that the service is often faster and sometimes slower; (*c*) the rates for weights up to 70 lb. are similar to those for parcels forwarded by passenger train at the railroad company's risk; (*d*) the rates for weights of more than 70 lb. are similar to those for small lots of goods forwarded by "goods train"; (*e*) a tariff of higher charges for private packages is used and (*f*) goods that

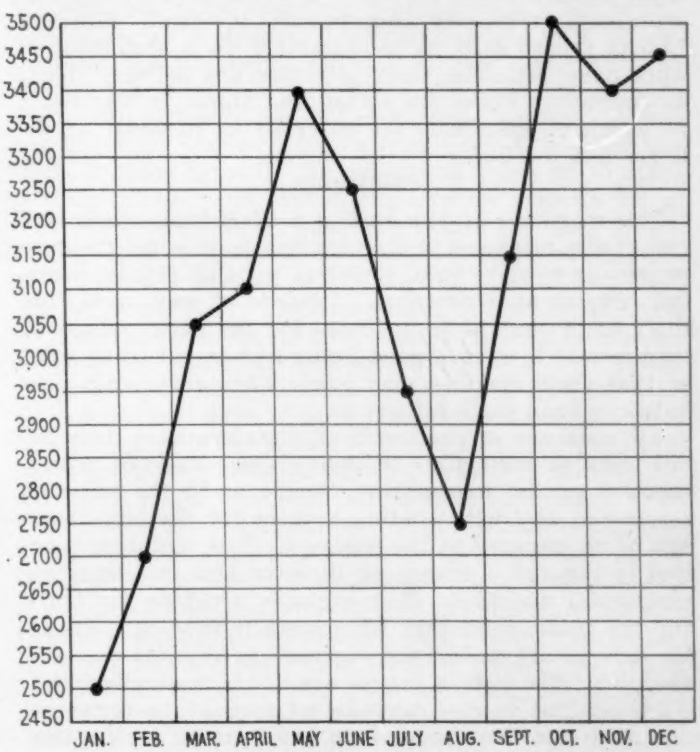


FIG. 4—CHART SHOWING HOW THE TRAFFIC FLUCTUATES FROM MONTH TO MONTH

The March and October Peaks Are Caused by the Spring and Autumn Clothing Traffic; That in May by the London Season and the December One by Christmas Presents. The Valley in January Is Caused by Winter Weather; That in August by the Holiday Season. To Minimize These Depressions "Stores Sales" Are Held in the Winter Months and in July, While the Transportation of Baggage in Advance of the Holidays Is Relied upon in August

TABLE 1—TARIFF CHARGES ACCORDING TO ZONES, CONVERTED AT 2 CENTS = 1 PENNY

Weights, Lb.	Zones, Cents				
	1	2	3	4	5
2	12	12	12	12	12
3	12	14	14	14	14
5	16	18	18	18	18
7	18	18	18	20	20
11	20	22	22	28	28
15	22	26	26	30	34
20	24	28	28	36	40
30	28	34	34	36	40
40	34	40	40	44	52
50	36	42	42	52	60
60	38	44	44	52	60
80	42	48	52	60	66
112	48	52	64	68	76
Each Additional 28 Lb.	9	10	12	14	18

can be handled easily and that are consigned chiefly to shops located on main streets, are charged a lower rate.

Regarding the system, on arrival at a depot all packages brought in are entered on sheets as a record of the driver's work. After sorting and while loading to a transfer truck, a brief record is made of all that goes onto it, as well as notes of any damage. The truck body is then locked and the note goes with it. On arrival at the delivery depot, the contents are checked off with the record and sorted into districts, a delivery sheet being made out and handed to the district driver with the goods; this he must bring back signed by said recipient against this entry about his goods.

The carriage charge is usually paid on collection of the goods, but it can be forwarded or paid monthly. Some goods are sent for value to be collected on delivery, especially from city warehouses to small retailers. Depots report daily to headquarters on a statement of work done, attaching their collection and delivery sheets as vouchers. These are sorted and stored in one room, to which all questions are referred as to proof of delivery and the like.

Personnel

The members of our staff are of British stock, and one of the pleasures a director has is to come to know personally so many men, girls and boys, all sturdy, cheerful, efficient and courteous. Leaders of men know that their employes are in business for the same reason as themselves; to earn a good living and to put aside a bit so that their families may have, when they start, less handicap than their fathers had.

All members of the board of directors have done detail work at some time in their lives. They fix policy, sanction capital expenditure, decide as to the value of assets and deal with trading surplus for the best interests of all engaged in the business. The executive function is through a managing director and the usual departmental divisions. The engineer provides the truck and the traffic chief says what work it is to do. Transfer drivers are under the engineer as regards pay and discipline; the district trucks are under the traffic chief. We think that success depends not so much on organization as it may be specified on paper as on seeing that all employes work in harmony.

Reliance is placed on a few statistics and much seeing of the men at work. If men and horses look to be in athletic condition, there is seldom much wrong. All employes are taught that carelessness is their worst competitor and public confidence their best friend. Also, that their duty is to be keen about their work; to learn it thoroughly and qualify for promotion; to obey cheerfully and cause others to obey them readily; to be proud of the business they are in; and to be courteous to the public and to each other.

Plant Equipment

Horses are used for short distances, on routes where standing still is frequent and the movement cannot be fast. Collection from customers' houses in the towns is made generally with horse-drawn vehicles, since the horse is a cheap and detachable unit and a self-starter. We are making horse-drawn trucks with ball bearings and light-metal covers; nearly all have fixed tops and earn a little by displaying other people's advertisements as well as our name. Pair-horse wagons are being replaced by electric or by gasoline-propelled trucks. The horses are used mainly in single-horse wagons and are capable of trotting while drawing about 2800 lb. of goods.

Transfer Trucks

Table 2 gives brief information about five types of truck. Type 2 is built specially for our work to provide maximum efficiency on good roads that have few hills. Its units can be changed readily so that a broken one can be replaced without putting the truck out of service. Such changes mean that no truck is the same truck by the end of 2 years of service; it is the sort of truck we want, except where the work is severe.

Type 1 has been altered from the standard builder's pattern, because it was found unnecessarily powerful for our work. We have reduced the bore of the cylinders and altered the gear-ratios. Trucks of this type that habitually draw trailers on short trips retain the normal size of cylinder. The constant-mesh gears were altered

TABLE 2—DATA RELATING TO THE MOTOR VEHICLES USED

Details	Type of Vehicle				
	1	2	3	4	5[a]
Size per Ton of 2240 Lb.	4	4	1½	1	2
Propulsion	Gasoline	Gasoline	Gasoline	Gasoline	Electric
Class of Service	Point to Point, Main Roads, Chiefly in the Country	Point to Point in London	Country and Suburban Deliveries	Leight Weight in London and Suburban Deliveries	London Deliveries
Power Developed, at 1000 R.P.M., hp.	35	24	20	25	....
Type of Drive	Bevel Gear	Chain	Worm Gear	....	Chain
Maximum Gear-Ratio	6½ to 1[b]	8½ to 1	5 to 1	5.1 to 1	....
Fuel Consumption, miles per gal.	7.0[c]	8.5[c]	9.5[c]	14.0[c]	....
Type of Tire	Solid Rubber	Solid Rubber	Solid Rubber	Pneumatic	Solid Rubber
Tire Mileage:					
Front	25,000	26,000	20,000	7,200	11,450[d]
Rear	30,000	32,000	20,000	7,000	11,700[d]
Average Mileage Run by Each Vehicle Last Year	31,400	19,000	10,400	15,300	7,471
Weight of Vehicle with Body, Unladen, lb.	10,528	8,372[e]	5,010[e]	2,688	5,544[f]

[a] Central motor with the control box located under the driver's seat.

[b] Double-reduction gear in the rear axle.

[c] At a volume equal to that of 10 lb. of water.

[d] In the future, it is expected that the tire mileage for the electric trucks will be as good as that for the tires on the Type 3 gasoline-driven trucks.

[e] These vehicles weigh less than the loads that they carry.

[f] Without the battery.

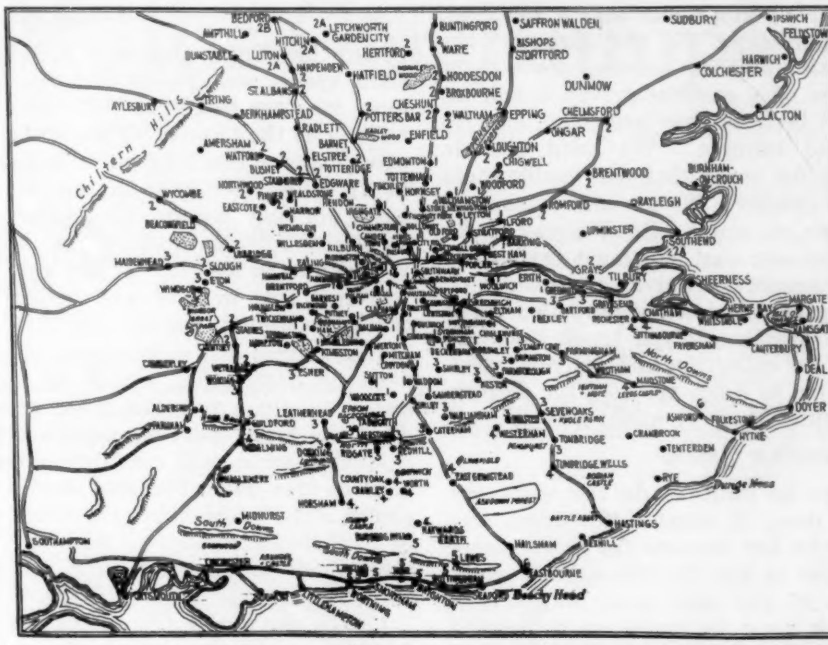


FIG. 5—THE CARTER-PATERSON DELIVERY SERVICE COVERS THE 10,000 SQ. MILES SHOWN IN THIS MAP
The Towns Served Are Indicated in Capital Letters and the Adjacent Figures Give the Zone in Which the Place Is Located. The Rates Are Based on the Distance Covered and Are Given in Table 1

to decrease the engine speed for the same speed on the road, which gives better results in the London streets. Often, these trucks are used by one driver from early morning to mid-day and by another driver for the remainder of the day. Types 1 and 2 have bodies of wood-frame construction and metal covers; they are 13½ ft. long, 6 ft. wide and 6½ ft. high inside and have doors at the back. Each weighs about 2000 lb. and is fitted with four eyes, by which it can be raised from the chassis by a four-point-suspension lift.

A transfer truck that comes into a depot passes under a lift by which its body is removed. Then it goes on, has a loaded body placed upon it and drives away at once. The loaded body that was removed is lowered on to a four-wheel flat truck that is switched to the sorting platform at a point where it is wanted. We hope soon to have a traveling lift on rails on our platform roof, which will obviate switching and will enable us to place truck bodies on the roof while not wanted, thus saving yard space. A chassis can have three or more bodies to serve. It is only in this manner that we have been able to attain with motor trucks the same flexibility of service that obtained with horse-drawn vehicles, when a pair of horses could be unhitched from a wagon and hitched to another wagon within a few minutes. The trailers we use are flat trucks built of steel and have rubber tires. A trailer is built to carry one of the removable truck-bodies.

Delivery Trucks

Type 3 of Table 2 specifies our delivery truck, which has three styles: (*a*) to carry 2500 lb. at 18 m.p.h., using pneumatic tires; (*b*) to carry 3350 lb. at 12 m.p.h., using solid rubber tires and (*c*) to carry 4500 lb. at 10 m.p.h., using solid rubber tires. The units are the same in each of styles (*a*), (*b*) and (*c*) and can be changed readily; the engine speed, the gear-ratio and the springs are different for each style. The fast style is supplied on a rental basis to stores to use for their home deliveries. Styles (*b*) and (*c*) are used for country or suburban delivery by district men.

The bodies of the style (*a*) trucks are built for appearance and advertisement. Those of styles (*b*) and (*c*) are built for convenience and, although they are loaded from the rear when in a depot, an entrance is made beside the driver's seat so that he can easily pick up a package from the body to deliver it, or bring a package he has collected to the body in the same way, thus saving the time otherwise taken in running around his truck. The driver of a delivery truck has a boy as a helper, provided the boy earns his cost by the extra work he enables the driver to do. These delivery trucks make more than 100 calls per day at different houses. Allowing 2½ min. for each stop means over 4 hr. that the truck is standing still. An average distance of 40 miles per day at 10 m.p.h. would complete the other 4 hr. of an 8-hr. working-day. The engines are adjusted to idle quietly at slow speed when the truck is standing still, as we have found no self-starter that will withstand 100 starts per day. The men prefer to have their hours not too rigidly fixed, as they realize that all reasonable needs of the public have to come first.

Type 4 is a motor vehicle that you know well and, if it were not what it is, it would not have been sold in millions. We are trying to find a rival to it, built on the lines of our usual practice and made in four types: a 1-ton truck, a traveler's car, a type for garage work and another for passenger use. Such a vehicle would have a four-cylinder engine and a three-speed gearbox in one unit, central control, a propeller-shaft to a worm or bevel drive, detachable steel wheels with pneumatic or cushion tires and a gilled-tube radiator. We want trucks to last 10 to 12 years in our work without having the repair bills become too high. We have more than 30 trucks of a type similar to Type 1 that were bought before 1911 and that are still doing good work; this at no depreciation expense, since we write off values in about 7 years.

Electric Vehicles

We use the electrically driven truck on district work that is beyond the capacity of the horse, but within the range of the electric truck. This range is found to vary

according to the number of stops and starts required, as well as according to mileage. If the range of the electric truck were greater and its running costs more noticeably less than those of a gasoline-driven truck, we should use more of them because they are clean, easy to handle, self-starting and reliable. We need electric trucks that have capacity for speed that will enable them to return to their depots quickly. We are also interested in them because we have no crude oil. We can make electricity by burning our own coal and must try to use it for as much of our transport power as possible.

We are here comparing the electrically propelled truck as we know it with the gasoline-driven truck that has been designed especially for collection and delivery work in London. We should like to learn more of the electric truck and the sphere within which it would help us.

The Vehicle Needed

If a motor truck is to be built to do the work the horse-drawn truck now does, it must differ from any yet used. The cost must be low because few horse-users with us can borrow money to pay for the extra cost of a motor-truck. We pay 17 per cent more wages to a motor-truck driver, which must be made up by having the machine enable the man to do more work in a day, if other costs are equal. As horse-drawn trucks have to stand still loading or unloading for more than ½ day and have a range of 3 to 12 miles only, the scope for quicker movement to get more work done is small. We have tried a motor truck equipped with a very small gasoline engine but would like to see more designs of electric and of gasoline types.

Buildings

Our buildings are very simple. The chief need is yard space, well paved and fenced. For sorting packages, we have platforms 3 ft. above the ground; they are as long as the number of trucks to be dealt with requires, often have a frontage on both sides and are from 30 to 50 ft. wide. We have no machinery for handling packages, not only because the distance each has to move is so short, but also because the packages vary so greatly in size and in weight. If any vehicle can be devised that will cost less in time and in money than does a hand truck, we want to see it.

Our stables and motor-truck sheds are so simple as to need no description, except to say that great thought has been given to make them simple. In telling about what the horse does, we refer to the very limited duties that the horse will perform when the conversions we have in view from horse to mechanical traction are completed. The problem on which we want help from others of experience relates to how far this conversion from the animal to the mechanical form of power for transportation service ought to be carried.

Lastly, the entire transportation business has no room for idleness or dishonesty. It makes men of those who engage in it, because most of them work out-of-doors, have to care for the property of others and must act so as to do in the best way what others want done. It affects us all, throughout life. Our Prince of Wales has said, "We need transport from the perambulator to the hearse," and I hope my tale of one little phase of it has interested you.

DEVELOPMENTS IN MOTORBUS-BODY DESIGN

(*Concluded from p.* 351)

tion of time until the industry will come to this plan, realizing that radical developments in motorbus-body design are a thing of the past. It will be a big step forward when some association proposes a code of standardized practice.

Summary

The factors in body design that affect the ultimate scope of motorbus transportation lie in the realm of greater safety and comfort for the passenger. Progress in providing greater head-room and knee-room, and lower floor and step levels, will depend upon the economic pressure brought to bear on specialized manufacturers who supply materials for motorbus-body construction. Body builders who avail themselves of improved materials are paving the way for further developments along this line and, hence, are aiding the ultimate success of motorbus transportation.

DENSITY OF POPULATION IN RUSSIA

PERHAPS because before the war Russia was the foremost grain-exporting nation of the world, the idea seems to be more or less entertained in the United States that it is a country of wide spaces and few inhabitants like Canada, Australia and Argentina. While this is true of Siberia, nothing could be farther from the truth so far as concerns Russia-in-Europe. The population is dense in comparison with the other chief grain-exporting countries of the world, with the exception of British India and the countries of the Danube basin. In 1913, in Russia-in-Europe, exclusive of Finland, there was an average of nearly 72 persons per square mile. At that time there were 32 persons to the square mile in continental United States, between 7 and 8 in Argentina, 2 in Canada and less than 2 in Australia. In British India and the Danube countries the population is much denser than that of Russia.

European Russia is a country of poor peasants. From 1858 to 1913 its population, exclusive of Finland, increased from less than 70,000,000 to 143,000,000 and the population of Asiatic Russia from less than 10,000,000 to about 30,000,000. Eighty-five per cent of the people of European Russia live on the land. A large proportion of the peasantry has long been at the margin of subsistence, famine having swept the country at intervals. That of 1921 was not exceptional in Russian history.—E. M. Miller, National Bank of Commerce.

Motor-Car Bumpers

By JOHN R. REYBURN[1] *Illustrated wtih* DRAWINGS

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

A BUMPER is a bar attached transversely in front of or behind a car body to prevent contact between an obstruction and the car body, or to cushion the shock of collision between vehicles. The impact bars have various sectional forms, from flat to round and from tubes to channels, and are composed of steel, wood or rubberized fabric. The attaching devices are sometimes yielding, sometimes rigid. The evolution of the bumper is shown in the records of the Patent Office. Early types had yielding attaching-parts and rigid impact-parts. These were followed by types having a rigid bar connected with the frame by only a spiral spring, by those having channel-steel impact-bars and others having round spring-steel extending from the frame-horns. A strip of rectangular spring-steel was then used by a Western blacksmith, and later a similar non-reinforced bumper appeared which was cut in two in the middle, the ends being overlapped and the overlapped parts clamped together. For several years development was limited to these types. Then appeared a loop-end type in which the impact-bar was spread vertically. This led to the introduction of many bumpers having an extended impact-surface. In 1914 or 1915, resilient bumpers that demonstrated their protecting possibilities on cars traveling at the rate of 15 m.p.h. were introduced. These offered an elastic yielding resistance that built up in intensity in proportion to the magnitude of the shock and to the available clearance.

Designing the most protective bumper consists simply of providing the maximum allowable clearance and arranging the structure to make full use of this clearance under the maximum impact. The limit of protection is determined by the rate of retardation the most expensive parts of the car will withstand and by the practical limitations of cost, weight and clearance.

The Underwriters' Laboratories, applying central impact-tests to a stationary bumper, obtain deflections comparable with those produced in 10-m.p.h. collisions. But the minimum and the maximum deflections should be specified in order that bumpers may be gaged not only for the prevention of contact but for the amount of cushioning that is to be provided.

The tempering of springs is essential to maintain the original shape of the bumpers that take full advantage of the available clearance in their protective action. Soft-steel bumpers may be made which will provide all possible protection for one collision, but after several slight collisions soon become objectionable in appearance.

In recent years few other accessories have been so unsatisfactorily attached to automobiles as have bumpers. However, provision for their application has been neglected by car manufacturers. One or two additional holes would greatly simplify the labor of attaching them and would also reduce the cost to the car-owner. Bumpers at the same elevation on colliding cars are twice as effective as those of different elevations. Although specifications cover this height, many bumpers fail to conform to them. An appreciation of the protective power of bumpers and closer cooperation between car manufacturers and bumper manufacturers would result in a reduction of the growing list of automobile casualties.

ANY substantial bar transversely attached ahead of or behind a car body is called a bumper. These bars, more or less convex and from 55 to 65 in. wide, are attached from 17 to 24 in. above the surface

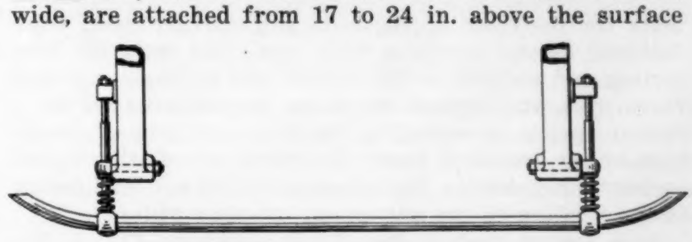


FIG. 1—ONE OF THE EARLY METHODS OF ATTACHING BUMPERS
In This Type the Front-Spring Bolts Were Replaced by Eye-Bolts and Second Members Also with Eyes Were Fastened Farther Back. A Rod Fastened to the Impact-Bar Was Free To Slide through These Eyes and a Helical Spring Surrounding This Rod Forced the Impact Bar Outward. These Springs Provided Some Cushioning when an Object Was Struck

of the road. Their purpose is to prevent contact between an obstruction and a car body and to cushion the shock of collision between vehicles proceeding at rates of speed exceeding a very few miles per hour.

The impact bars have various sectional forms, from flat to round, from tubes to channels, and are composed of steel, wood or rubberized fabric. Besides single impact-bars, many constructions have reinforcing members not unlike girders at the rear.

The attaching devices, in some cases, include yielding and, in other cases, rigid members, usually fastened to the frame, with isolated attempts at connection with the axles or the springs. Linkages engaging both the frame and the axle also have been proposed with the idea of translating horizontal thrusts into vertical components tending to lift or to depress the body.

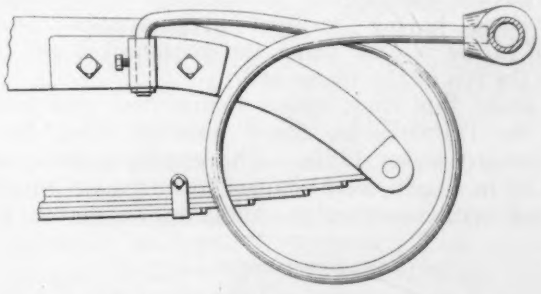


FIG. 2—ANOTHER EARLY TYPE OF BUMPER ATTACHMENT
The Impact-Bar in This Method Was Attached by a Round Spring-Steel Member Having a Complete Vertical Loop Midway between the Impact Bar and the Point of Attachment to the Frame. Regardless of Any Distortion of the Impact Bar This Supporting Means Insured Some Resilient Action

United States Patent records show pioneer bumpers composed of tubular-steel bars, straight except for the ends, which curve rearward. The attachments were of three types. One, the Harroun, Fig. 1, substituted eye-

[1] M.S.A.E.—Engineer, American Chain Co., Bridgeport, Conn.

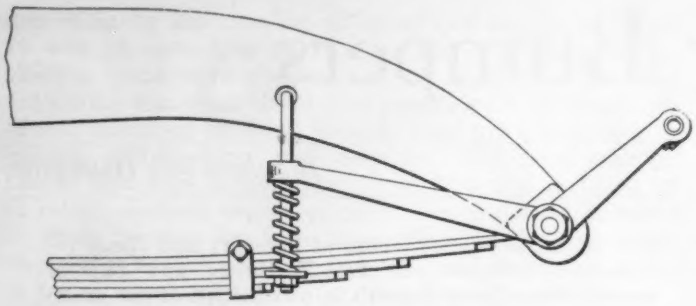


FIG. 3—THE THIRD OF THE EARLY FORMS OF ATTACHMENT
The Tubular Impact-Bar Was Connected to the Outer End of Bell-Cranks That Were Pivoted at the Front-Spring Bolts and Had a Spring Connection at the Inner Ends. Since the Bell Cranks Extended Diagonally Upward a Resilient Action Was Provided on the Arc of a Circle Having the Spring-Bolts as a Center

bolts for the front spring-bolts and, farther back, were fastened second members with eyes. An inwardly projecting rod secured to the impact bar slidingly engaged these eyes, the impact bar being forced outward by a helical spring surrounding the rod. On impact, some cushioning resulted from the yielding of the spiral springs, provided the sliding supports did not bind owing to the bending of the impact bar or other causes.

In a second bumper, the Olson, shown in Fig. 2, the impact bar was attached by a round spring-steel member having a complete vertical loop midway between the impact bar and the point of attachment to the frame. This means of support assured resilient action, regardless of the distortion of the impact bar.

A third designer, Sager, connected the tubular bar with the outer end of bell-cranks extending diagonally upward, pivoted at the front spring-bolts and having spring connections at the inner ends, as shown in Fig. 3. This bumper provided a resilient action on the arc of a circle having the spring-bolts as a center.

CHARACTERISTICS OF EARLY BUMPERS

It should be observed that these bumpers had in common yielding attaching-members and rigid impact-bars, a type that has survived to date on a small scale. In 1909 or 1910 appeared an impact-bar, not unlike heavy high-pressure hose, supported at three intermediate points by S-shaped springs made of strip-steel. This was known as the Welton and is illustrated in Fig. 4.

Then followed a rigid bar connected with the frame by only a spiral spring. Channel-steel impact-bars appeared, some having semi-elliptic spring-steel supporting-members, some having resilient supporting-members, S-shaped in the vertical plane and goosenecked for fastening to the top of the frame end.

At about this time, round spring-steel was extended from the frame-horns, flared outward, then forward, then inward about 18 in. The opposing ends, spaced about 24 in. apart, were coupled to a tubular impact-bar provided with contracting nuts, as is shown in the

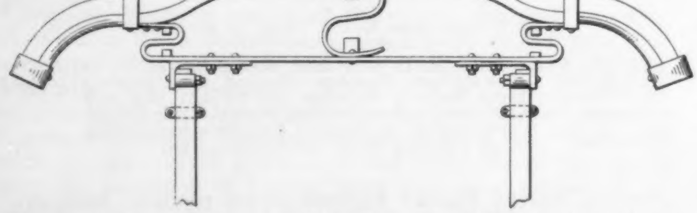


FIG. 4—A TYPE OF IMPACT BAR THAT MADE ITS APPEARANCE IN 1909 OR 1910
This Impact Bar Greatly Resembled Heavy High-Pressure Hose and Was Supported at Three Points by S-Shaped Springs Made from Strip Steel

Fageol type, Fig. 5. This bumper took care of different frame-widths by moving the ends within the central tube inwardly or outwardly, the adjustments, of course, altering the transverse spread of the impact-bar.

EMPHASIS PLACED ON CUSHIONING

It should be noted that throughout this period many minds centered on cushioning the impacts by resilient supporting-members, few realizing the possibility of resilience in the main bar. Then a typical Western blacksmith, Hoover, brought a 10-ft. strip of rectangular spring-steel from his stock to the forge, shaped the intermediate 5 ft. for the front of the bumper as others had done, brought the ends backward and looped them inward and again backward, combining the impact-bar and the supports with spring action throughout. Later, on finding the middle too yielding, he reinforced it by

FIG. 5—A BUMPER CONSTRUCTED OF ROUND SPRING-STEEL AND A TUBULAR IMPACT-BAR
In This Type Pieces of Round Spring-Steel Extended Forward from the Frame Horns and Were Successively Flared Outward, Forward and Inward for Approximately 18 In. The Space between the Opposing Ends, Approximately 24 In., Was Filled by a Tubular Impact Bar Having Contracting Nuts. Adjustment for Different Frame-Widths Was Made by Moving These Ends Inward or Outward within the Central Tube, Thus Altering the Transverse Spread of the Impact Bar

attaching a strip of spring steel similar to the straight portion of the front bar, as is shown in Fig. 6.

Subsequently, the Lyon combination-bumper appeared. This was substantially formed of a similar non-reinforced bumper, but was 3 ft. wider, was cut in two at the middle, the ends were overlapped about 3 ft. and the overlapped portions were clamped together, as is indicated in Fig. 7. This also provided for different frame-widths, changing however the bumper spread.

THE LOOP-END TYPE

For several years development was limited to these types. Then appeared a loop-end type in which the impact bar was spread vertically. This was known as the Pancoast & Grotenhuis and is illustrated in Fig. 8. The early popularity of this larger impact-surface led to the appearance of many extended impact-surface bumpers. Modifications include double and triple fronts, interconnected at or near the ends with a single auxiliary rear bar or to supports. This is the status of bumpers today.

But it was not until 1914 or 1915 that any national publicity appeared concerning bumpers that could and would demonstrate their possibilities at 15 m.p.h. Telephone poles and brick walls were rammed at this speed without injury to the car or its component parts, and all for the now simple reason that the bumper was resilient throughout, that wherever struck it exerted an elastic yielding resistance that built up the intensity of the resistance in proportion to the magnitude of the shock and in proportion to the available clearance.

THE MOST PROTECTIVE BUMPER

Obviously, designing the most protective bumper consists simply in providing the maximum allowable clearance and arranging the structure to make full use of this clearance under the maximum impact. The limit of protection is determined by the rate of retardation that the more expensive parts of the car will withstand, and by the practical limitations of cost, weight and clearance.

Offhand, any point along the impact bar should be constructed to withstand the maximum blow. At its center, until recently 18 in. of clearance before contacting with the radiator could be counted upon. That allowed 18 in. within which the car might be brought to a stop; not much when one realizes that a 3200-lb. car at 15 m.p.h. possesses 290,000 in-lb. of energy. With the present prevailing tendency toward cross-struts at the extreme frame-ends, this clearance is reduced to about 10 in., so that a much stiffer central portion is now necessary.

Ahead of the frame-ends a generous clearance is about 7 in. An impact of sufficient force to cause a central deflection of 10 in. might then be expected to bend the bar opposite the frame-ends, namely, 7 in. Beyond the tires the customary clearance is from 3 to 4 in. On the same theory, a bumper should be several times as stiff at the tip ends, but other factors enter into each of these cases. Actually, the tip ends of any bumper are necessarily weak in relation to other parts, but in this regard prevailing conditions assist. Most tip-end collisions occur when the front wheels are turned to one side, materially augmenting the clearance. Moreover, the tip end, upon deflecting, exerts an inclined-plane action that tends to divert the obstruction from the car, or vice versa; the tire, when struck, also has a cushioning effect.

Frame-End Is Vulnerable

Of the various points of contact, the frame-end is rather vulnerable, inasmuch as sharp impacts at this point develop the full retarding-force in one side-member, whereas an end-blow promotes side-skidding, and a central blow is absorbed equally by both side frame-members and occurs at a point where standard construction provides a large clearance. Beyond the frame-horn the bumper cannot be extended much, for obvious reasons. At this point it must be designed to build up its resistance rapidly to a point where a greater retarding-force would injure car parts that are expensive to repair; and it must take complete advantage of all the available clearance. Tip ends overhang the supporting points about 25 per cent. Effective arching and bracing are necessary to develop the requisite strength to produce the desired protective action against retarding and skidding.

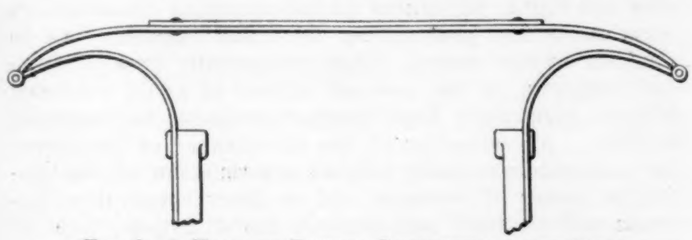


Fig. 6—A Form of Bumper Developed in the West
This Bumper Was Made from a 10-Ft. Strip of Rectangular Spring-Steel with the Central 5 Ft. Forming the Front of the Bumper Shaped in the Usual Way. The Ends Were Brought Backward, Looped Inward and Then Backward, Thus Combining the Impact Bar and Its Supports with Spring Action Throughout. Subsequently the Middle Portion Was Reinforced by Attaching a Strip of Similar Spring-Steel to the Straight Portion of the Front Bar

How much protection a first-class bumper should afford and what are its identifying characteristics are by no means simple to determine. One bumper-manufacturer has shown "movies" of a 3500-lb. car purposely driven into a tree at a speed stated to be 22 m.p.h. and reputed to be 26 m.p.h. These "movies" show further that the car, uniformly retarded by the bumper action, recoiled backward a few feet and was then driven off, apparently none the worse for wear. The bumper, of course, was left semi-circular in shape, concave outwardly.

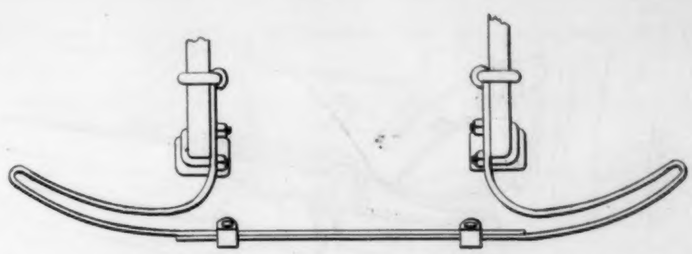


Fig. 7—A Combination Bumper That Was Capable of Adjustment for Different Frame-Widths
This Bumper Greatly Resembled the One Shown in Fig. 6 before the Reinforcing Strip Was Applied. It Was However 3 Ft. Wider, Was Cut in Two at the Middle and the Overlapping Portions That Were About 3 Ft. Long Were Clamped Together. In Making the Adjustment for Different Frame-Widths, the Spread of the Bumper Was Changed

Underwriters' Tests

The Underwriters' Laboratories apply central impact-tests to a stationary bumper that produce deflections in the bumper comparable to those produced by 10-m.p.h. collisions, when the bumpers are attached to light, medium or heavy cars in accordance with their classification. The maximum allowable-deflection is the main consideration in these tests. It seems that it would be better to apply end and intermediate tests, and to specify the minimum and the maximum deflections in all cases, in order that the bumpers may be gaged not only for the prevention of contact but also for the amount of cushioning to be provided. Just how far the Underwriters' Laboratories can go in assuring a degree of protection depends on how far the effect of price competition is permitted to influence protection and serviceabilty. Like most problems, this seems to be a matter of education. At all events it is well within commercial bounds to designate a good bumper as one capable of protecting against 15-m.p.h. collisions, and such a requirement should worry no modern conscientious bumper-manufacturer.

The tempering of the springs is essential to maintain the original shape of the bumpers that take full advantage of available clearances in their protective action. Soft-steel bumpers may be constructed which will provide all possible protection for one collision, but the light collisions actually occurring with surprising frequency in normal service soon render their appearance decidedly objectionable. Testimony was submitted in a recent case that about 80 per cent, by actual count, of the spring-bar bumpers of an unheat-treated type in service in one of the large cities were obviously distorted.

Importance of Easy Application

Much time has been devoted to analyzing bumpers, both historically and from the operating standpoint, and little reference has been made to the attachments, which are, however, of prime importance. Few other accessories have been so unsatisfactorily attached to automobiles in recent years as have bumpers It is not uncom-

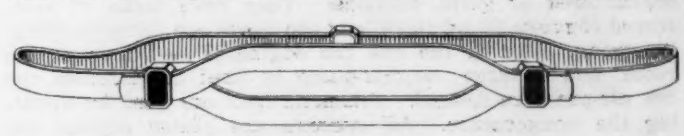


Fig. 8—A Loop-End Type of Bumper in Which the Central Portion Was Spread Vertically
This Larger Impact-Surface Immediately Became Popular and Led to the Appearance of Many Extended Impact-Surface Bumpers. Modifications of This Design Include Double and Triple Front-Bars That Were Interconnected at or near the Ends to a Single Auxiliary Rear-Bar or to Supports

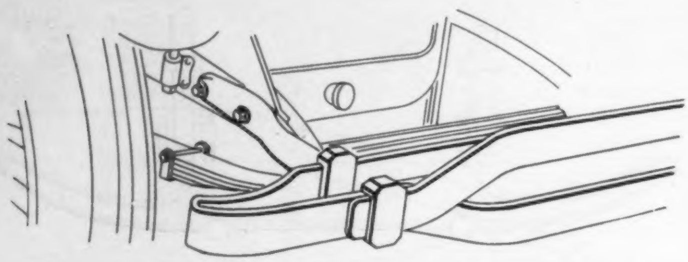


FIG. 9—FITTING FOR ATTACHING BUMPERS
This Fitting Is Designed for Use on a Car That Has the Necessary Holes Punched in the Frame before It Leaves the Factory

mon to see bumpers tipping in the air, with one end up, down, in or out. Formerly, the entire frame-horns were available and applications were simple and substantial. Then splash-pans were introduced between the frame-horns and because of them fenders were extended to the tips of the frame. Later the frame-horns were concealed. Cooperation between bumper manufacturers and car builders was conspicuous by its absence, with the result that bumper manufacturers found open to them simply a lower flange of a channel-section to which to attach solidly with any degree of universality a device that inherently should be most solidly attached. The alternative was a wide range of bulky and expensive forged and cast fittings, the removal of spring-bolts or frame rivets, the drilling of holes and the like.

Automotive engineers, beginning with the four-wheel 10-hp. buggies of 1903 that could scarcely be depended upon for more than 25 miles without adjustment to the under side, have busied themselves with acceleration, retardation, electric cranking and lighting, Pullman comforts, mechanical windshield-cleaners and pumps, with the result that the eighth wonder of the world has been produced. With this recognized triumph, the newspaper head-lines continually record the attendant casualties, and "safety-first" campaigns are continually heralded. In spite of this indication of protection as one of the great fields of activity of today, provision by car builders for the application of bumpers has been conspicuously neglected. On the other hand, the attachment of snubbers has been excellently provided for by the simple expedient of punching a hole in the frame at some specified point.

One or two additional holes, or one hole and the substituting of a bolt for one of the outward frame-rivets at a predetermined point, would greatly simplify the attaching of bumpers and at the same time assure their durable application at considerably less expense to the car-owner.

At present a commercially-good means of attaching a bumper is truly a work of art and unnecessarily expensive. A simple solution, though not complete, has been standardized by the Society but can hardly be described as adopted. Fig. 9 shows a simple and serviceable fitting, designed for a car that is punched with suitable holes before leaving the factory.

It might seem a simple solution to drill the frame as required, when attaching a bumper. It is simple, and in time this solution may develop; but up to the present the public seems to prefer a bumper attachment that can be put on in a private garage with a monkey-wrench, in spite of the fact that this is seldom done.

EFFECTIVENESS OF BUMPERS

Another important S.A.E. Standard relates to the height of bumpers. Bumpers at the same elevation on colliding cars are twice as effective as bumpers having different elevations. With the prevailing tendency toward wide-face bumpers or double-bar bumpers, large plus and minus tolerances on the standard elevation are permissible and practicable, yet many bumpers fail to conform to this range. This is especially true of rear-end bumpers, in the case of which, to avoid extended fittings, excessively high bumper-elevations are common practice. A realization of the significance of the growing automobile casualty-list, an appreciation of the protective power of bumpers and a closer cooperation between car builders and bumper manufacturers are all factors of importance in the continuing expansion of automobiles.

NEW ALTITUDE CHAMBERS TO BE SAFER

PREVENTION of a recurrence of the accident in September, 1923, in which four men were killed, has been the object of the redesign of the altitude chambers of the Bureau of Standards, the reconstruction of which is now nearing completion. While every possible precaution has been taken to prevent explosions, it is not safe to rely on prevention alone. The altitude chambers have therefore been designed in such a way as to reduce to the minimum danger to employes and to the building in case another explosion should occur.

These altitude chambers are used for testing aircraft engines under the conditions of low air-pressure and cold encountered at great altitudes. They have walls of reinforced concrete 16 in. thick, and the doors are correspondingly strong. During the test the engine is sealed up in the room, and a large vacuum-pump is used to maintain the low air-pressure desired. Ammonia coils are used for lowering the temperature. All controls are placed outside the chamber and no one is inside during the test.

In the explosion last year the doors of the exploding chamber were blown outward into the laboratory. The explosion, escaping into the laboratory, blew out every window in the building, steel sash and all. As rebuilt, necessary doors to give access to the altitude chambers are designed so that they are more than able to withstand the pressure that may build up should an explosion occur in the chamber. To limit the maximum pressure to a low figure, special large openings are provided at the rear of each chamber. These openings will have special covers designed to withstand an external pressure of about 1400 lb. per sq. ft. resulting from operation of the chambers under vacuum. These coverings will, however, give way very quickly when subjected to pressure from the inside. This will be accomplished by depending for strength on a frame of heavy steel plates, placed so as to offer the minimum resistance to the passage of a blast, and covering this framework on the outside with a layer of very light material of high heat-insulating quality, the latter being so connected to the plates as to be easily blown off by the inside pressure.

Short wide passages formed by heavily reinforced concrete walls connect the safety openings in the chambers directly with the outside of the laboratory building so that in case of an explosion, the escaping gases and debris cannot reach the personnel. This plan of protection was tried on small-scale models before being incorporated in the design and is expected to prevent serious damage to the chamber, while offering as complete protection to the personnel as human ingenuity can devise.

Applicants *for* Membership

The applications for membership received between Aug. 15 and Sept. 15, 1924, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ALLEN, GERALD H., president, Allen Electric Mfg. Co., *Detroit.*

ANDERSON, JOSEPH A., inspection foreman, A. C. Spark Plug Co., *Flint, Mich.*

BAKER, CHARLES F., sales engineer, Dayton Steel Foundry Co., *Dayton, Ohio.*

BERGER, F. LESLIE, engineer, J. G. Brill Co., *Philadelphia.*

BLANCHARD, ARTHUR H., professor of highway engineering and highway transport, University of Michigan, *Ann Arbor, Mich.*

CARTER, ROBERT HILL, secretary and general manager, Richmond Forgings Corporation, *Richmond, Va.*

CHOU, CHENG-YU, draftsman, Pierce-Arrow Motor Car Co., *Buffalo.*

CUMMINGS, FRANK J., 359 Mosholu Parkway, *New York City.*

DASBACH, R. G., director of education, Chicago Automotive Institute, *Chicago.*

DAUGHERTY, DON, chief draftsman, Adams Axle Co., *Findlay, Ohio.*

FITZMARTIN, PAUL, mechanical draftsman, R. S. Kent, Inc., *Brooklyn, N. Y.*

FREDERICH, CHARLES W., test engineer, General Motors Corporation, *Detroit.*

GLASS, JOE A., service-manager, C. J. Siors Motor Co., *Pittsburgh.*

GOESELE, GUSTAVE A., mechanical engineer, International Motor Co., *New Brunswick, N. J.*

GOETZ, JULIUS J., president and treasurer, Western Metal Specialty Co., *Milwaukee.*

GREEN, MAURICE W., junior aeronautical engineer, National Advisory Committee for Aeronautics, Langley Field, *Hampton, Va.*

GUENTSCHE, HELLMUTH, mechanical engineer, Yellow Coach Mfg. Co., *Chicago.*

HANSEN, CHRIST, assistant body engineer, H. & M. Body Corporation, *Racine, Wis.*

HEITSHU, D. CROMER, instructor in agricultural engineering, Virginia Polytechnic Institute, *Blacksburg, Va.*

HIATT, H. I., sales agent, National Malleable & Steel Castings Co., *Chicago.*

HILL, CARLTON, engineer and patent attorney, Charles W. Hills, *Chicago.*

HILL, J. BENNETT, chief research chemist, Atlantic Refining Co., *Philadelphia.*

HOLLER, WILLIAM E., vice-president and general manager, Flint Motor Co., *Flint, Mich.*

KELLY, LEO ALFRED, special representative, Motor Wheel Corporation, *Lansing, Mich.*

KREUDER, ADOLPH H., superintendent of motor transportation, Indiana Refining Co., Inc., *Lawrenceville, Ill.*

LUCHT, FREDERICK WILLIAM, chief engineer, Goddard & Goddard Co., *Detroit.*

LOSEE, JAMES R., resident engineer, C. M. S., Inc., *Tarrytown, N. Y.*

LUNDGREN, CARL GUSTAV, salesman, National Malleable & Steel Castings Co., *Cleveland.*

MCGINNIS, P. B., sales and engineering representative, Westinghouse Air Brake Co., *Wilmerding, Pa.*

MCPHERSON, C. J., sales manager, J. G. Brill Co., *Philadelphia.*

MILLER, JOHN A., president, C. M. S., Inc., *Tarrytown, N. Y.*

MITTEN, RAYMOND FLOYD, field engineer, Automotive Maintenance Machine Co., *Chicago.*

MODRE, MILTON G., superintendent of trucks and buses, Boston Elevated Railway, *Boston.*

OLECK, THOMAS A., research engineer, Fellows Gear Shaper Co., *Detroit.*

OPPENHEIM, B. J., president and general manager, Barter-Oppenheim, Inc., *Newark, N. J.*

PEARSON, LEVINE, service manager, Hill Motor Sales Co., *Oak Park, Ill.*

PLATEAU, A., managing director, Raffinerie de Petrole du Nord, *Wasquehal, Nord, France.*

PURVIS, JUDSON A., shop foreman, Texas Co., *Chicago.*

REID, ELLIOTT GRAY, assistant aeronautical engineer, National Advisory Committee for Aeronautics, Langley Field, *Hampton, Va.*

SELLARDS, FRANK B., engineer, Stromberg Motor Devices Co., *Chicago.*

SHERWOOD, E. H., salesman, National Malleable & Steel Castings Co., *Cleveland.*

SMITH, C. H., vice-president, Westinghouse Union Battery Co., *Swissvale, Pa.*

SPERRY, EDWARD D., engineer, Dura Co., *Toledo.*

STEVENS, CARL A., mechanical engineer, Pierce Petroleum Corporation, *Sand Springs, Okla.*

STEWART, D. HENRY, chief of standards department, Kelsey Wheel Co., Inc., *Detroit.*

TAYLOR, HERBERT A., California representative, H. H. Taylor & Co., *Los Angeles.*

TIMPF, CHARLES R., chief inspector, Spicer Mfg. Corporation, *Pottstown, Pa.*

TRUMP, CHARLES C., engineer of tests, Atlantic Refining Co., *Philadelphia.*

WALKER, HUBERT, assistant chief draftsman, General Motors Truck Co., *Pontiac, Mich.*

WEINHARDT, ROBERT A., chief engineer and assistant to president, Erd Motors Corporation, *Saginaw, Mich.*

WINSLOW, CHARLES A., engineer, Winslow Mfg. Co., *Vallejo, Cal.*

Applicants *Qualified*

The following applicants have qualified for admission to the Society between Aug. 10 and Sept. 10, 1924. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member; (E S) Enrolled Student.

ADAMS, CHARLES W. (A) manufacturing engineer, United States Graphite Co., *Saginaw, Mich.*

AHLBERG, DANIEL F. (A) tool designer and assistant superintendent, Clark Cutter Co., *Detroit,* (mail) 295 Richton Avenue.

BAXTER, HENRY N. (M) mechanical engineer, Ward Motor Vehicle Co., Mount Vernon, N. Y., (mail) 423 West 120th Street, *New York City.*

BLATZ, RAY W. (A) Racine Radiator Co., *Racine, Wis.,* (mail) 1327 Carlisle Boulevard.

BRASHEAR, W. R. (A) assistant general sales manager, Moon Motor Car Co., *St. Louis,* (mail) 5225 Waterman Avenue.

BURNS, CHARLES L. (M) assistant to works manager, Wright Aeronautical Corporation, *Paterson, N. J.*

CLEGG, LEE M. (A) sales manager, Steel Products Co., 2196 Clarkwood Road, *Cleveland.*

DAVOCK, H. N. (M) technical service-manager, Packard Motor Car Co., *Detroit.*

DOLLINGER, L. L. (M) president and engineer, Staynew Filter Corporation, 99 North Water Street, *Rochester, N. Y.*

DONOHOUE, S. E. (A) assistant engineer, A. L. Powell Power Co., Cleveland, (mail) Gateway Hotel, *Quapaw, Okla.*

DUNWOODIE, DAVID M. (M) factory manager, engineering division, Air Service, McCook Field, Dayton, Ohio, (mail) Haver Road and Rubicon Drive, *Oakwood, Dayton, Ohio.*

EASTWOOD, GEORGE W. (F M) department manager, Arrol Johnston, Ltd., *Dumfries, Scotland,* (mail) Lochar House.

FLADER, FREDRIC (S M) assistant aeronautical engineer, engineering division, Air Service, McCook Field, Dayton, Ohio, (mail) Cox-Klemin Co., *Baldwin, N. Y.*

GANS, ROBERT S. (A) president, Columbus Co., Columbus, Ohio, (mail) Hotel Imperial, *Detroit.*

GFROERER, HERBERT (M) assistant to the assistant to the president, Cadillac Motor Car Co., *Detroit,* (mail) 10 Longfellow Avenue.

HAZEN, R. M. (M) instructor in mechanical engineering, experimental engineering laboratories, University of Minnesota, *Minneapolis.*

HOAG, CHAUNCEY A. (M) engineer of tests, Hayes Wheel Co., *Jackson, Mich.,* (mail) 1215 Michigan Avenue, West.

HUGHES, JAMES J. (A) service-manager, Mack International Motor Truck Co., *Pittsburgh,* (mail) 102 Virginia Avenue.

JACOBS, CHARLES W. (A) service-manager in charge of retail and wholesale service, Pence Automobile Co., 800 Hennepin Avenue, *Minneapolis.*

JONSSON, SWEN M. (J) engineer, International Motor Co., *New York City,* (mail) 371 West 116th Street.

LANG, JOHN F. (A) designing draftsman, J. G. Brill Co., *Philadelphia,* (mail) 7007 Wheeler Street.

MCKEE, L. Z. (A) manager of sales, Canedy Otto Mfg. Co., *Chicago Heights, Ill.*

MCMULLIN, RAY D. (J) 2814 Eighth Avenue, *Rock Island, Ill.*

MORITZ, WILLIAM H. (J) engineering department, International Harvester Co., *Akron, Ohio.*

NEUWOEHNER, HIRAM (A) assistant purchasing agent, Moon Motor Car Co., *St. Louis,* (mail) 2333 Tennessee Avenue.

OHSAWA, GEN (J) P. O. Box 191, *Flint, Mich.*

READ, CLARENCE E. (A) service-manager, J. W. Robinson Co., *Lawrence, Mass.,* (mail) P. O. Box 328.

REMSEN, ALFRED H. (A) service-manager, Rickenbacker Motor Co., *Detroit,* (mail) 1742 Atkinson Avenue.

RODD, WILLIAM C. (M) Detroit Athletic Club, *Detroit.*

RUMP, OTTO H. (A) chief draftsman, Ross Gear & Tool Co., *Lafayette, Ind.,* (mail) 1717 Union Street.

SAWDERS, F. P., JR. (A) general manager, Pittsburgh Truck Mfg. Co., *Pittsburgh,* (mail) 4715 Wallingford Street.

SMITH, HERBERT (A) sales manager, Manley Mfg. Co., *York, Pa.*

SMITH, NORMAN J. (M) general superintendent of transportation, Consumers Co., *Chicago,* (mail) 4458 Grand Boulevard.

STETLER, CHARLES ERNEST (A) production manager of motor transportation department, Light Mfg. & Foundry Co., *Pottstown, Pa.,* (mail) 67 Edgewood Street.

WARD, FRANK H. (M) designing engineer on dies, presses and general pressing of steel, A. O. Smith Corporation, *Milwaukee,* (mail) 933 45th Street.

WILBER, CARL L. (A) manager of forge division, Timken-Detroit Axle Co., *Detroit,* (mail) 8100 East Jefferson Avenue.

WILLS, JAMES (J) machine designer, S. & S. Machine Co., New York City, (mail) 1122 54th Street, *Brooklyn, N. Y.*

YEAGER, LEO RICHEY (A) general manager and secretary, Yeager Tilt-O-Lite Co., *Columbus, Ohio,* (mail) 290 Kelso Road.